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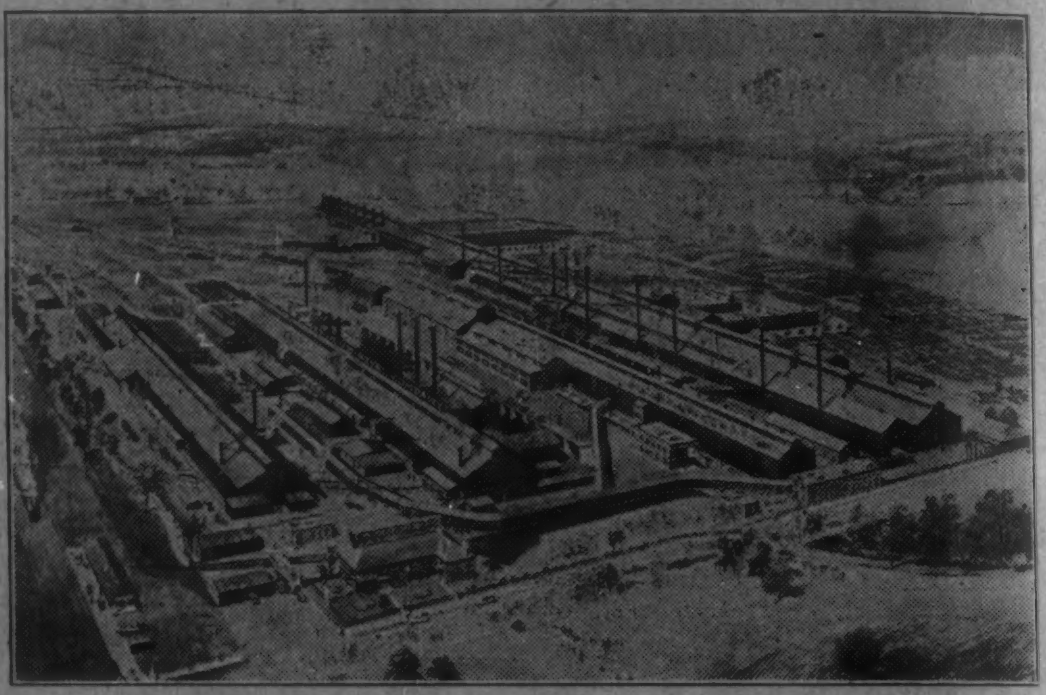

The LUDLUM STEEL COMPANY first started business in 1854. The plant was rebuilt in 1906—entire new machinery and mill equipment installed—since that time the plant has been doubled in size and equipment.

Every rolling mill is electrically driven. Our own design electric crucible furnaces are exclusively used in melting our steels.

Our product, from the raw material to the finished bar, is repeatedly inspected chemically and physically by specially trained inspectors and controlled by highly technical men.

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LESSONS LEARNED IN THE MANUFACTURE OF MUNITIONS AND ORDNANCE THAT CAN BE APPLIED TO THE PEACE-TIME PURSUITS OF INDUSTRY.

By F. V. Larkin.*

It is the purpose of this paper to point out certain lessons, learned in the manufacture of munitions and ordnance, that can be applied to the peace-time pursuits of industry.

The conclusions on which these lessons are based were established in the period extending from 1915 to 1919, during which the author was associated in the manufacture of some three million projectiles and a half million high pressure seamless cylinders. They are drawn from the viewpoint afforded one in charge of operations, whose duty and privilege it was to deal with the production, heat treatment, and fabrication of steel, the organization and training of the men who did the work, and with the officials who administered the procurement of munitions and ordnance for the Allied Powers, and for the United States Army and Navy.

These lessions thus naturally divide themselves into two groups, those having their origin in the realm of steel, and those having their origin in the realm of human nature.

Starting from the standpoint of steel in the open hearth development will be made through the forge shop, heat-treating department, testing department, up to and including the men who did the work.

In the open hearth we found that a complete history of each open hearth heat, originated in the open hearth, and compiled by the operators themselves, went far to eliminate the darkness and semi-mystery that too often surround the production of steel — particularly the production of off heats.

Most open hearth men must necessarily get the knowledge of their jobs, first by word of mouth, and later by experience, rather than by personal study. For these reasons they become careful and accurate observers. Like most uneducated men, they have an undue aversion for writing down any specific statement, or if they cannot write, to making any definite assertion that is to be written down on their authority. Then too, such men have an undue fear of truthfully stating that they have done something wrong or, that they have made a mistake. As a consequence, they keep away from the necessity of reporting discrepancies, with the result that the quantity and quality of their operation is raised.

In the rolling mill we reached the conclusion that much of the expense of chipping ingots and blooms can be eliminated by a reasonable care in the preparation of moulds and rolling. In substantiation of this, it may be of interest to know, that the company whose operation is being cited, never chipped one single billet of steel for over three million projectiles, and that their former practice of chipping ingots made for cylinder plates was abandoned.

As to the forge shop, a pyrometer in the forge shop pays.

In spite of the dire predictions of the superintendent of the forge department a radiation pyrometer was installed in the projectile forge shop. This revealed, as had been assumed it would, too wide a range of forging temperature. Uniformity of heating followed, and with it two wholly unlooked-for beneficial results, namely, a decrease in the number of forging tools required, and a decrease in the number of defective and eccentric forg-

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ings. This pyrometer was mounted on a piece of pipe bent in the form of an L and hinged so that it was normally held up and out of the way by a counterweight. As the forgings were placed open end up in an inspection pot, the pipe carrying the pyrometer could be drawn down so that the bottom of the cavity was always exposed a uniform distance from the pyrometer end.

In the heat-treating department it was found that furnacemen should be taught enough of the operation and use of the pyrometer to enable them to look upon it as an aid to their work rather than as a tell-tale of their operation.

A recording pyrometer was installed near the drawing end of a long continuous coal-fired annealing furnace. The furnace was used for drawing quenched steel to a carefully predetermined temperature and was normally so fired that the steel was slowly heated at first, reaching its maximum temperature under the pyrometer. The fireman was duly impressed with the necessity of producing a uniform curve on the chart in the superintendent's office. Soon it was discovered that all the steel was coming uniformly soft. Early investigation showed that the correct drawing temperature had been prescribed and that the fireman had maintained his fires so as to produce a perfect chart. Then followed a checking of the pyrometer, a checking of chemical analysis, a review of the history of the heat and its progress through the plant up to the furnace again. Here further investigation showed that the fireman had learned that by firing the charging end heavily he could best produce a uniform curve on the pyrometer chart. The result was that the steel was overheated shortly after charging, then cooled down to the proper temperature when it passed the pyrometer, and drawn out of the furnace looking normal.

We also found that time is a vital factor in the heat treatment of steel.

In order to maintain constant the temperature of the steel, the quenching medium, and the cooling water, it was found well to synchronize the operations of charging, drawing and quenching with a gong which indicated the desired interval. Annealing furnaces happened to be so arranged that they could also be governed by the same gong. Under normal conditions the operation was as follows: On the stroke of the gong, the piece in the quenching bath was withdrawn and charged into the annealing furnace, a piece was drawn from the quenching furnace and placed in the quenching bath, and a corresponding charge of the hot furnace and discharge of the annealing furnace made.

The result was that time in heating furnace was constant, time in quenching bath was constant, time in drawing furnace was constant, pounds of steel quenched per hour was constant, all of which was conducive to uniform firing and uniform speeds for oil pump and circulating water pump. The operation went on day and night six days a week with remarkable uniformity.

In the testing room it was established that the ordinary testing machine can be adapted for hardness testing and for gauge testing in an emergency.

Our hardness testing equipment was destroyed by fire. Before it could be replaced the necessity for making hardness tests arose. A supply of steel balls of the proper size was obtained. One of these was magnetized and placed on the upper compression head, the machine reversed and the required load applied. The process was, of course, too slow for production, but apparently satisfactory.

The production of one thousand pieces per day, each of which were required to withstand a hydrostatic test to three thousand pounds per square inch, made it necessary that a supply of accurate gauges be maintained. Formerly the manufacturer of the gauges had made repairs and calibrations, but in the stress of the emergency it became impossible to get adequate service. Accordingly an oil plunger gauge-testing device was made up, so proportioned that there would be an even decimal ratio between beam reading and gauge reading. This placed in the machine, operating in compression, made it possible to produce any desired oil pressure and thereby calibrate the gauge. Arrangement was, of course, made for turning the piston of the gauge tester to eliminate friction. This device calibrated against a gauge, certified by the Bureau of Standards, showed remarkable accuracy.

This concludes the discussion of those lessons having their origin in the realm of steel. Passing now to the second group, which have their origin in the realm of human nature, development will be made under the two headings: trade secrets and specifications.

Prior to 1914 practically all our knowledge of munitions and ordnance was confined to a few companies who held an ungrudged monopoly on the production of armament and implements of warfare. Such discoveries as were made during the period of limited expansion of our Army and Navy, were carefully guarded as trade secrets, justly enough considered the property of the companies who had evolved them. So apparent was this that in 1915 a writer in one of the technical magazines made the prediction, that if the United States should become involved in the war, it would take three years to develop the necessary tools and gauges adequate to cope with the situation.

It is an apparent anomaly that from the very ranks of those thus formerly charged with the responsibility of hoarding and monopolizing the secrets of the art of the heat treatment of steel, there should spring such an organization as The American Society for Steel Treating. Particularly is this true, in view of the Society's statement, that one of its specific purposes is "to collect, publish and disseminate knowledge." Shades of Samuel Gompers! A strict adherence to the precepts of trade unionism, on the part of those engaged in educational work, would require that they look upon this attempt to disseminate knowledge, as an infringement upon the province of their profession.

But we are all coming to the conclusion that it is erroneous to hold that the bulk of our educational work is done in the schools, that it is likewise erroneous to contend that the only teachers are those whose remuneration comes from the specific task of teaching. Every industry is an institution of education, and all the leaders in it are teachers, whether they consider themselves teachers or not. The Society's entrance into the field of education is implied in their quotation from the immortal Roosevelt: "Every man owes some of his time to the upbuilding of the profession to which he belongs." Therefore this occasion for joining hands with you in an interchange of ideas is welcomed, quite as much as the opportunity it affords of greeting you as a fellow educator.

Not only were we confronted at the outset with the trade secrets referred to, but the arts of systematic shop production and inspection and the manufacture of tools and gauges were likewise beyond the realm of our experience and, therefore, to us, trade secrets. We attacked these vari-

ous handicaps from a pedagogical standpoint, which in the last analysis holds that secrets are relative things. That is to say, what is a secret to one man is an axiom to another. So we made a rather daring classification and placed secrets in the same category with ghost mysteries, ouija boards, superstition and ignorance. Then we laid down and defended the maxim that the other fellow's secret was of less value to him than our ability and determination to unravel it were to us. We soon realized that, knowing the fundamental principles which serve as a foundation for any secret or process, we had only to bring into operation a sufficient amount of logically directed and persistently applied energy and ability, to duplicate or outstrip the achievements of our competitors.

The manner in which our leaders and workmen responded to teaching was so splendid and so satisfactory that we found a lack of experience was a handicap of much less consequence than a lack of spirit. The conclusion established in regard to trade secrets follows: If the spirit of your organization is right you can make every trade secret bearing upon your work, an incentive rather than an impediment.

In regard to specifications, it was found that the more strictly a set of fair and accurate specifications are required to be met, the better it is for the manufacturer and the men doing the work.

The preparation of specifications is an art. Particularly is this the case in specifying steel and its performance in service. No doubt many of you encountered crude, cumbersome, arbitrary specifications, prepared in haste and fear, and bearing little evidence of a knowledge either of the possibilities or of the actual requirements. The overlapping and conflicting elements of such specifications must be brought into line before any production can be forthcoming. Otherwise, demoralization and stagnation result, due to the fact that the energy and ability of the organization doing the work will be applied in a negative manner designed to show why requirements cannot be met, rather than in a positive direction determined to meet them.

At this point reference is made to what may be considered a masterpiece in specification writing, and tribute is paid to Colonel B. W. Dunn, Chief Inspector, Bureau of Explosives, Interstate Commerce Commission, for the specification known as I.C.C.3A, covering shipping containers. Carefully and accurately prepared, they are of the most rigorous and exacting nature. Yet they are fair. They can be met by the manufacturer, and they insure to the customer a product which he can purchase and use with a maximum assurance of security and safety.

Success in meeting such specifications brings gratification and pride to the workmen and to their leaders, and at the same time puts the manufacturing process on a high plane, not only raising the quantity and quality of the product, but also the spirit and ability of the men. In general, the poorest grade of work which a customer will accept, is the best that a manufacturer can possibly coach his men to produce. We taught our leaders and workmen the specifications involved in their particular departments. We taught them to know when their product was right. We taught them to stop wasting time on the repair of questionable stuff. We taught them never to ask a customer or his representative if a product was good enough. Our maxim was "Know your product is right, then present it to the customer with satisfaction and pride and he can do only one thing—accept it."

So thoroughly did this work out, that our management received a most unusual complaint from one customer's representative. Complaint was

made that the Company's Inspector was rejecting work which he, the Customer's Inspector, would be willing to accept. Such, you are assured, was not the case. Rather, the Customer's Inspector was a man whose idea of inspection necessarily involved rejection. When he found little or nothing to reject, he felt that his perogatives were being usurped. For such inspectors—and they were not all such—it is sometimes wise to permit a percentage of low-grade work to be presented in order that the authority and prestige of the customer's representative may be exercised in the rejection of some of the pieces submitted.

Notwithstanding incidents of this nature, it is felt that the demonstration of the statement first made was established. The more strictly a set of fair and accurate specifications are required to be met, the better it is for the manufacturer and the man doing the work.

In conclusion, a summation of the items discussed follows:

1. A complete history of each open hearth heat, compiled by the operators themselves, pays.

2. Much of the expense of shipping ingots and blooms can be eliminated by a reasonable care in the preparation of moulds and rolling.

3. A pyrometer in the forge shop, pays.

4. Furnace men should be taught enough of the operation and use of the pyrometer to enable them to look upon it as an aid to their work rather than as a tell-tale of their operation.

5. Time is a vital factor in the heat treatment of steel. It furnishes a logical base around which to develop a heat-treating operation.

6. The ordinary testing machine can be adapted for hardness testing and for gage testing in an emergency.

7. If the spirit of your organization is right you can make every trade secret bearing upon your work an incentive rather than an impediment.

8. The more strictly a set of fair and accurate specifications are required to be met, the better it is for the manufacturer and for the men doing the work.

9. Finally, in the equipment of any individual, personality is of more importance than technique. That is to say, unless the individual professing a knowledge of the art of steel making, has the ability to set it forth in terms simple enough to inspire a belief in him, if not an understanding of his dogma, he will not be able to materially increase either the quantity or the quality of the output of a plant.

DISCUSSION OF MR. LARKIN'S PAPER

MR. HILLMAN: I wish to state that since starting operation of our plant, our open hearth plant man makes a complete report on each person, and in going over that report personally from time to time he has increased the efficiency of our product now about thirty per cent from what it was when the plant was first started about two years ago. It is not only an incentive to him, but also an incentive to the men who work under him, and it has proven very much of a success and has given us a prestige among other plants. Other plant representatives and persons who have had occasion to visit our plant and look over our product have sort of "sat up and took notice," so to speak.

THE RELATION OF THE STEEL SALESMEN TO THE DEVELOPMENT OF HEAT TREATMENT OF STEEL

By Guy P. Bible*

(A Paper Presented at Philadelphia Convention)

It is a real pleasure to speak before this convention and have the opportunity of joining in the discussion of this work, which will mean so much to the future progress of the world.

There are some phases of heat treating which come before the salesman in most forcible, insistent, and at times embarrassing ways, and if the total accomplishment of this paper is to put before the chemists and metallurgists on one side, and the shop men on the other side, some of the difficulties we have to face, without doubt it will have done a little good.

Probably not all of you have heard the salesman's own particular, personal and best loved poem; it is brief, so that its repetition will not weary you.

He who whispers down a well,
About the things he has to sell,
Will never make as many dollars,
As he who climbs a tree and hollers.

Now the steel salesman knows a lot about wells and trees when it comes to heat treatment. He frequently hears of a customer who is in a well, only we speak of it as a hole, and he is often up a tree as to the cause of the difficulty. Unless he can help his customer up out of his particular hole, the salesman is in the hole himself. If it is characteristic of the mill people, and of sales managers to say when trouble is reported, that the fault lies, not in the steel, but in the treatment, and this is true in probably 90 per cent of all complaints, and in this fact lies the opportunity of the salesman to aid in the development of heat treatment.

The function of the steel salesman in this work, is largely that of a "thinking sponge" if such a thing were possible. He must absorb on every occasion, knowledge as to theories, methods and practice. He must apply to this knowledge the maximum reasoning power of which he is possessed, so that when occasion required, he can give out this information, in a logical, authoritative and helpful manner. He must get his information from many sources; from matallurgists, chemists, engineers, and from books and papers and lectures. But he must also get it from the blacksmith, the tool hardener, the tool maker, the machinist, the die designer, the foreman and the superintendent, and the whole line of practical men who have done so much to develop this subject, and who in the last analysis, are the fellows who translate into actual being all the prior efforts of the steel maker, chemist and metallurgist. The steel salesman then, has everything to learn, but he has something also to teach, and the man who will seriously consider this phase of his business will be the better salesman, the better man, and will make the most of his opportunity to contribute to the progress of the world.

A brief consideration is now in order of the conditions which face the steel salesman, and particularly the tool steel and the alloy steel salesman, and which he must correctly analyze and solve if he is to keep his customer, his house and his own particular self free from the many difficulties entering into the use of steels. He should by all means get full information from the user, as to the purpose for which the steel will be used, so that proper selection of grade and temper may be made. Nor is this sufficient;

*Horace T. Potts & Co.

he should know what the heat treating facilities are in the shop, and if they are bad, poor, or insufficient, he should learn whether the customer would be willing to send out to a well equipped shop, the finish machined pieces for heat treatment. Nothing is ever gained by passing over these phases of a situation, in order to make a sale, and much good may be accomplished by an intelligent consideration of them. Furthermore, if this information is given the Sales Department, or the Mill, a grade may be selected which will require much simpler treatment, which would be well within the shop capacity. It sometimes requires courage and persistance to do these things, because the salesman might be in a sense, fighting both his customer and his Sales Department, and it may be that in cases like these, the laboratory can back up the salesman and help him and themselves.

The steel salesman cannot do any original work in heat treating, but because his greatest difficulties lie in three very common human traits—Ignorance, Carelessness and Conservatism—his accomplishment, if he overcomes these characteristics, is as truly helpful as that of the leader in the profession. "They also serve who only stand and wait." His greatest opportunities lie in two special directions: the most common, getting his customer out of trouble, and the other in helping to improve methods and equipment so as to make results already good, still better.

In most cases the customer is in trouble because of one or more of the traits mentioned. We have all met the man who says, "I have been doing this for years just exactly in the same way, and never had any trouble before." Or the other fellow who says, "The 'blank' steel which I used for years never gave me a broken tool." I have been married a number of years, but I don't know that I ever envied the fellows who say, "Well, I've been married twenty years and never had a harsh word with my wife." A broken tool now and then is relished by the best of men.

The trouble may be in the manner of heating, the time for heating, the heat itself, or in the method of quenching, the quenching medium, or in the drawing. The difficulty may be further back, and lie in the forging or annealing operations which may have preceded the actual heat treatment. The steel salesman should know his business well enough, that on occasion he may suggest an analysis of each operation, or even a micrographic analysis of the various operations.

The solution of the difficulty may lie in a simple thing like changing the quenching medium from water to brine, or even in washing out the quenching tank thoroughly. Sometimes the trouble may be obviated by plugging holes with asbestos instead of fireclay, and at other times the omission of such plugs entirely may be the answer. In our organization, we are great believers in the principle of pre-heating of all tools where any considerable forging or machining has been done. We believe it is the answer to most of our questions. We also are firm believers in brine for quenching, and the removal of the tool to oil just as soon as the heat has been sufficiently quenched as to prevent any rise in temperature after entering the oil.

In all that I have said before, I have had reference largely to the heat treatment of tool steel and tools, but there is another side of the heat treatment, which of course, appeals to a great many people. I have reference to the heat treatment of low carbon steels and alloy steels. For fifty years or more we were very large importers of Swedish iron and this material entered into work where the requirements were extreme in the way of resistance to fatigue, maximum elongation, and excellent welding

and forging qualities. The war necessarily shut off this importation, and not caring to turn to another iron, we have done some little work in the way of the heat treating of soft steels and alloy steels for work where the Swedish Iron formerly went in.

In addition our business has largely been along the lines of soft steel and high grade straight carbon machinery steels, and we have taken advantage of the opportunities given to, in very many cases, suggest heat treatment and assist our customers to inaugurate and carry through, such heat treatment to success. This field offers the greatest single opportunity for a long step ahead. Every one uses straight carbon steels and iron, and every one is coming into the use of alloy steels to some extent. The steel salesman by a study of steels and heat treatment, can assist overcoming most of the failures in service which are due to insufficient strength. Too much stress cannot be laid upon this side of the work of the steel salesman in relation to the development of the heat treatment of steel.

There is another phase of this subject on which I would like to speak briefly. The most enlightened self interest, if we do not wish to place it on a higher plane, would surely call for every effort to help the steel user. It is not enough at times to overcome these common and more or less elemental troubles in heat treatment. The cause for trouble may be more fundamental, and lie in poor equipment. insufficient appliances, and lack of knowledge as to the particular type of equipment necessary to correct the difficulties, or as so often is the case to meet new conditions due to expansion in production. The steel salesman can, especially if he has the confidence of the user, do a great deal in increasing interest in new furnaces, improve tanks, pyrometers, hardness testing instruments and the whole line of what might be considered more as laboratory equipment. It is true that the steel salesman is not, for instance a furnace salesman, but if for example a man is attempting to heat a long die in a furnace which will not even take it in, which condition we have all met at times, he is surely justified in saying something which will help to correct the evil.

If I may summarize in conclusion, I might say that the function of the steel salesman is to absorb all information obtainable, gladly and intelligently; to ponder over and digest this information with judgment and reason; and to in turn give it out, freely but modestly, with the one desire to help the other fellow in his little problems, realizing that after all the measure of a man's success is the assistance he has been able to give to his fellow men. The modern proverb, clothed in the language of the day has a lot of truth in it:

> Remember my son, that when the One Great Scorer comes to mark up, He sets down, not that you won or lost, but how you played the game.

THE EFFICIENCY OF VARIOUS QUENCHING MEDIUMS AND THEIR APPLICATION

Victor E. Hillman*

(A Paper Presented at Philadelphia Convention)

Hundreds of different quenching baths have been used in the past. Moreover, letters patent have been granted for fluids that are supposed to possess remarkable properties as quenching mediums. Regardless of the infinite variety of nostrums introduced, none of them has found a place in commercial use. On the other hand, however, the quenching baths which have found extensive application in the heat treating department are: Brine, water and oil. Each has its merits. Brine imparts the maximum hardness obtainable although its drastic action may cause the steel to crack if design and mass are not taken into consideration.

Water is an excellent quenching medium, but it should be used with discretion. Thin pieces of steel should not be quenched in water due to excessive distortion and their liability to crack. The writer has been unable to draw a sharp line of demarcation between water hardening and oil hardening steels, but the results of numerous investigations indicate that high carbon (1.10) low manganese (.25) steel may be classified as water hardening while high carbon (.90) in conjunction with a higher manganese (.65) will come under the category of an oil hardening steel. Experience has proven that if the high manganese steel is quenched in water the tool will invariably crack.

It is indeed surprising that water should show its maximum hardening power at 100° F.—See curve. This same result has been confirmed by several investigators. Furthermore, water between 180° F. and 200° F. shows a hardening power nearly equivalent to oil at 70° F., 150° F. and 250° F. Consequently, the results of this research would indicate that hot water could find more extended use as a quenching medium.

On the other hand, however, water lacks hardening uniformity. Its action is erratic, inasmuch as a change of 50° or 100° F. will alter the physical properties of the hardened steel.

It is the custom in some heat treating departments to use a water bath covered with a few inches of oil for quenching purposes. The oil layer prevents hardening cracks and mitigates the shock which is incident to quenching in water direct. Tools hardened in the aforementioned manner possess practically the same hardness as that obtained from water alone. Inasmuch as the quenching mediums cannot be circulated, this method of procedure lacks practicability for large plants.

The proper selection of a quenching oil is a prerequisite for successful results in the heat treating department. The following indices are excellent criteria of the adaptability of a quenching oil:

A—Hardening Efficiency.
B—Hardening Uniformity.
C—Viscosity.
D—Flash Point.

Hardening Efficiency

The hardening efficiency of a quenching medium is ascertained by an arbitrary method. The outline of procedure consists essentially in quenching a piece of steel of standard size and analysis in a standard

*Metallurgist, Crompton & Knowles Loom Works, Worcester, Mass.

volume of oil at different standard temperatures. The hardened Specimens are Brinelled and the value thus obtained is an index to the hardening efficiency of the quenching medium at the indicated temperature.

Some idea of the relative hardening efficiency of various oils can be obtained by comparing the several Brinell values obtained at some specific quenching temperature. By following the ordinate 70 in the subjoined graphs, it will be readily seen that the compounded oil possesses the maximum hardening power inasmuch as its Brinell value is 430, as against 390, 400, 360, 380, 380 and 400, for Fish Oil, Linseed oil, Cottonseed oil, Salmon oil, Lard oil and Whale oil respectively.

The hardening efficiency of the various oils can be obtained thru a range of 40° F. to 300° F. by referring to the curves.

Hardening Uniformity

It is quite essential that a quenching fluid should possess an appreciable range in which it will harden a piece of steel uniformly. The hardening uniformity is expressed by a set of graphs which have been plotted by using the temperature of the quenching bath as abscissa and Brinell values as ordinates.

The hardening uniformity can be ascertained by noting the tendency of the curve to remain in a horizontal position. The compounded oil and the mineral oil show very good hardening uniformity. As a general proposition, the various oils show practically a constant hardening uniformity—that is, the temperature of the quenching bath may vary considerably without appreciably affecting the final results.

Viscosity

Viscosity is the degree of fluidity which an oil possesses. Temperature is an important factor in the determination of viscosity. The temperature range, given in the sub-joined data, covers the minimum, intermediate and maximum temperatures which are likely to be encountered in quenching practice. Low viscosity determines the ease with which an oil can be handled. The hardening effect of a bath varies inversely as its viscosity. Briefly, the quenching speed is retarded as the oil increases in viscosity. The figures which are given are entirely arbitrary. The viscosity value 337 for Linseed oil at 70° F. signifies that it requires 337 seconds for 60 cubic centimeters of oil to pass through a standard orifice. When the oil is heated to 150° F., 60 cubic centimeters of the oil will pass through the same opening in 96 seconds.

Viscosity—"Saybolt"

Oil	70 Deg. Fahr.	150 Deg. Fahr.	250 Deg. Fahr.
Linseed	337	96	55
Cottonseed	328	91	48
Whale	294	85	46
Fish	...	850	169
Salmon	...	786	162
Lard—No. 1	275	93	40
Compound Oil	269	69	38
Mineral Oil	500	84	36

Flash Point

The flash point of a quenching oil is the lowest temperature at which it will emit sufficient vapor to effect momentary ignition (flash) when a lighted taper is brought to within one quarter of an inch of the surface of the oil. The flash point should be sufficiently high for safety. The flash point has no bearing on the efficiency of an oil as a quenching medium.

Oil	Deg. Fahr.
Linseed	537
Cottonseed	588
Whale	481
Fish	460
Salmon	471
Lard	446
Compounded oil	383
Mineral oil	410

CONCLUSION

In the comments that follow, the various oils will be discussed under their respective classifications; namely, animal, vegetable, mineral and compounded oils.

Animal Oils

The results of this investigation show that fresh animal oils possess good hardening efficiency and a wide latitude insofar as hardening uniformity is concerned. A decade or so ago, animal oils were used quite extensively in heat treating practice. In recent years, however, animal oils have been displaced, due to a lack of uniformity in the results obtained after prolonged use. Moreover, one shipment would give results which were entirely satisfactory, while another lot of the same oil would be the source of continual complaint. Another objectionable feature to the use of animal oils was that they decomposed on continual use. Decomposition is usually accompanied by an increase in viscosity and a consequent reduction in quenching speed. Therefore, the results of the tests embodied herein must be accepted cautiously. Even though satisfactory laboratory results are obtained, the commercial value of an oil can be ascertained only by practical tests.

Vegetable Oils

The values obtained for vegetable oils parallel the results obtained from animal oils. As in the above instance too much importance should not be attached to the apparent efficiency of the vegetable quenching mediums. It should be borne in mind that they possess the property of absorbing oxygen from the atmosphere. When an oil absorbs oxygen, its refrigerating properties are impaired. Therefore, it would appear that a vegetable oil cannot be relied upon as a uniform quenching medium even though the results of the hardening tests point to the contrary.

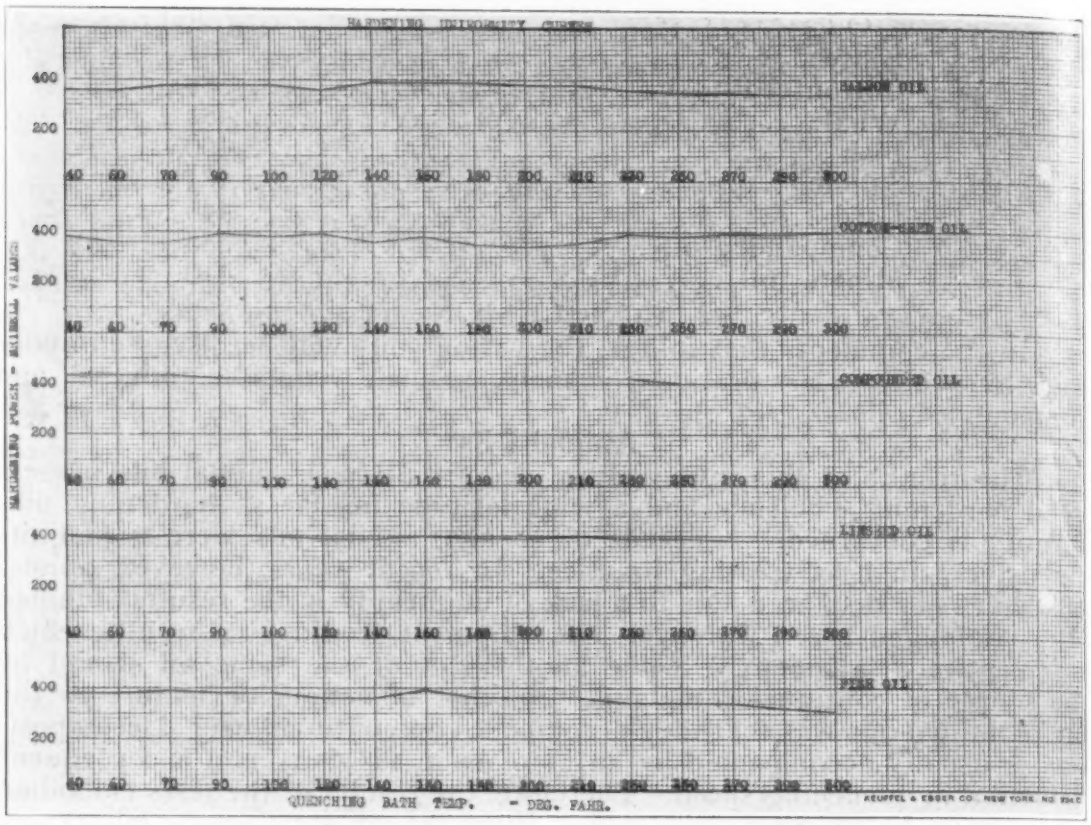
Mineral Oils

It is difficult to differentiate between the merits and demerits of a mineral quenching oil. The writer has known of cases where a mineral oil has given excellent results, but the duty imposed upon it was not severe. In other instances, mineral oils are reputed to have undergone fractional distillation to the extent that the oils would lose their fluidity and clog the pipes in the circulating system. There is a decided decrease in the efficiency of a quenching medium due to its becoming viscid. A test which was conducted some time ago showed that the tensile strength and elastic limit of test specimens decreased 13% and 14% respectively, due to the use of a thick oil as a quenching medium.

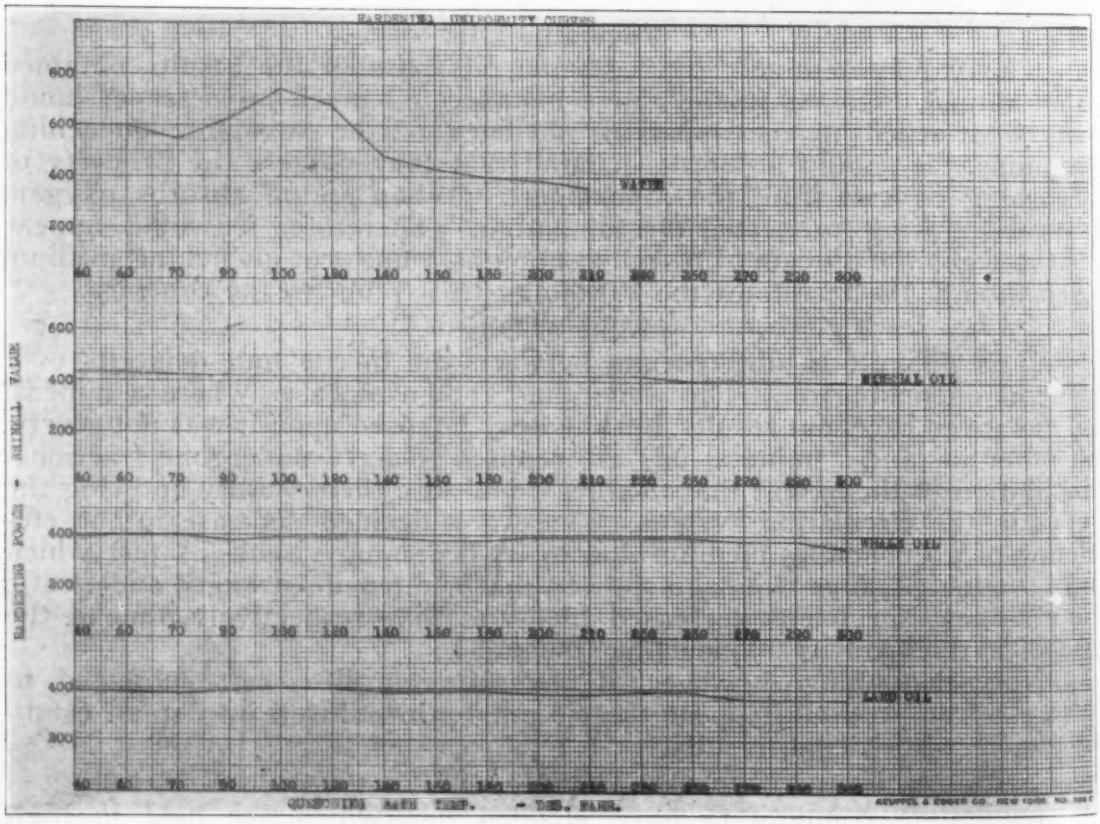
Notwithstanding, however, if the mineral oil is not subjected to severe usage, it would appear that it can be introduced into small establishments without bad results.

Compounded Oils

Numerous competitors have blended oils which are held in high



Hardening Uniformity Curves



Hardening Uniformity Curves

esteem by the average heat treater. It seems only natural that an oil which is compounded for a specific purpose should possess properties which are designed for the end in view.

The compounded oils not only show excellent hardening efficiency, hardening uniformity and low viscosity, but these properties remain intact after the oil is subjected to high duty.

Operating Data

Analysis of steel used. .....

Carbon	.89
Manganese	.55
Phosphorous	.03
Sulphur	.03
Silicon	.15

Dimensions of test speciments 7/8" round by 1/2" long.
The quenching bath was used still, free from circulation.
Volume of quenching medium, 5 gallons.
Steel quenched from 1475° F.

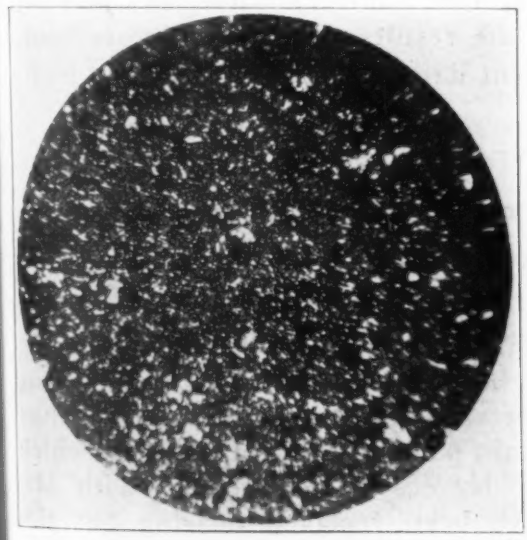
Quenching in High Speed Salts

The quenching of high speed steel in a molten chemical compound at a temperature of 1150° F. is productive of excellent results. Such a method of procedure serves a dual purpose, namely, the quenching and the drawing operations are combined.

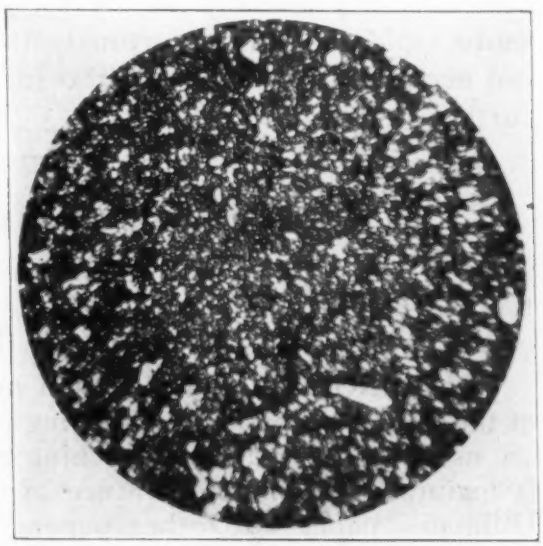
The treatment consists in heating the high speed steel to the desired temperature (22-2350° F.). The heated tool is then plunged into a molten quenching bath.

Another advantage incident to the above manner of quenching is that the tools after heat treatment are free from scale. Tools hardened in this way are also less likely to warp.

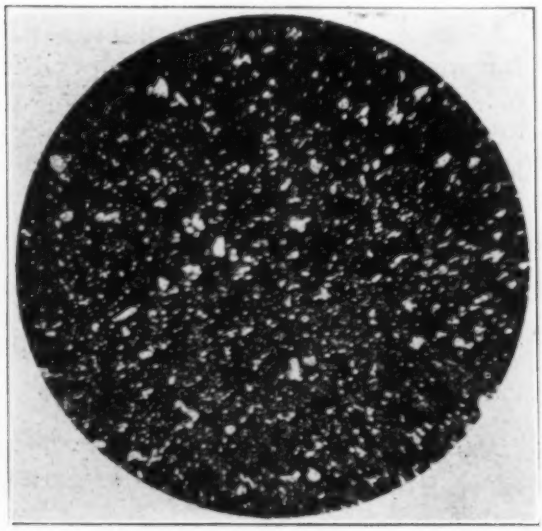
A set of microphotographs are embodied in this paper.



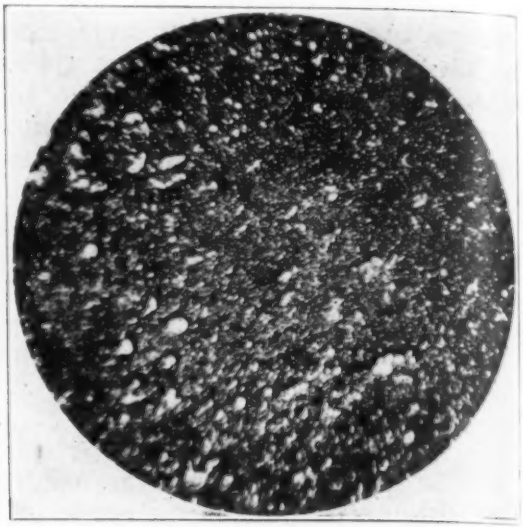
No. 1—High Speed Steel
Mag. 525× — 5% Nital Etch 7 mins.
Heated to 2,250° F.
Quenched in High Speed.
Steel Salts at 1,150° F.; then removed and cooled in air.



No. 2—High Speed Steel
Mag. 425× — 5% Nital Etch 7 mins.
Heated to 2,250° F.
Quenched in Molten (1,150° F.)
High Speed Steel Salts; then air cooled.
Drawn back to 1,150° F. in High Speed Salts.



No. 3—High Speed Salts
Mag. 425× — 5% Nital Etch 7 min. Heated to 2,250° F. Quenched in High Speed Steel Salts at 1,150° F. Then quenched in Compounded Oil.



No. 4—High Speed Steel
Mag. 425× — 5% Nital Etch 7 mins. Heated to 2,250° F. Quenched in Compounded Oil. Then drawn back in High Speed Steel Salts at 1,150° F.

Remarks:

The results of these experiments would indicate that eminently satisfactory results can be obtained by combining the quenching and drawing operations in the heat treatment of high speed steel. Except for a few coagulated carbide areas, all microphotographs show nearly the same micro-structure. Print No. 4 gives evidence of a finer carbide formation, which is due possibly to the fact that the transformation was arrested more rapidly. It is unfortunate that the results of practical tests could not accompany this paper, altho sufficient data has been divulged to incite further investigation.

DISCUSSION OF MR. HILLMAN'S PAPER

CHAIRMAN: You have heard Mr. Hillman's paper, and I know it represents a lot of work. I am sure all of you here use oil in some stages of the game, and I rather imagine there will be lots of questions.

MR. GREEN: Mr. Hillman may be interested to know that in one of the largest plants manufacturing a certain kind of machinery today they are using water bath for quenching certain parts of their machinery, which is maintained at a temperature of 105 degrees F. Coincident with Mr. Hillman's paper two other papers have been received bearing out the actual tests of the properties of water at 100 degrees F.

MR. GILLIGAN: There is another element enters into the problem of the quenching of steel, and that is the rapidity with which you get the liquid, either oil or water, there, and the velocity with which you pass through the critical range. Mr. Hillman's tests were carried out on small

sections, and still baths. Now in certain instances we have used oil sprays with high pressure, and taking the heat units away with the greatest rapidity possible, and we obtained hardnesses that approximated those with water at a temperature of 65 degrees F. Likewise, we have applied ordinary water at a pressure of eighty pounds per square inch with a fine spray and obtained hardness that approximated brine, but we avoided cracks by discontinuing the quenching operation at an elevated temperature. In other words, I think that the results that will be obtained will vary with the method of applying the quenching medium. That is set forth in considerable detail in the Transactions of the British Iron and Steel Institute on or about 1908.

CHAIRMAN: I think, following up the same line of argument, quite a little work was done in Holland about the year 1900.

MR. GILLIGAN: At one of the meetings of the Iron and Steel Institute in Great Britain, I think it was in the 108th Volume, it carries about 150 pages of matter, criticisms and papers presented.

MR. GRAHAM: There is one point in the paper that I would like to call attention to, and that is the question of quenching in hot water, or in a water bath covered with a film of oil, that is, half an inch, or two inches deep, or whatever the amount that may be put on it. Now there are a lot of you wonder why a tool hardener quenches a piece of steel in a water bath and then quickly takes it out and puts it in oil. I know I have heard a lot of argument pro and con from practical men, and they have never been able to give a real reason for it. Some don't believe it is the right practice. Now the actual reason, as I understand it, is that the quenching speed of the bath through the different ranges affects the breakage of the steel. You can quench through the critical range without the danger of breaking, but your breakage takes place below that. With an oil bath the rate of cooling is more or less uniform down to a low temperature, several hundred degrees Fahrenheit, while with the water bath this is not the case. You cool quickly through the critical range and the rate varies, and although you may start with hot water, which cools through the critical range at approximately the same speed as the oil, the speed varies when you are cooling thru the lower ranges, and it is at the lower ranges that the cracking takes place. Therefore, as I see it it is foolhardy to quench through oil into water and expect to eliminate breakage, because you may do away with the first shock, but you are not eliminating the real cause of breakage, and that is the cooling of the steel through the ranges below the critical range, that is, through eight hundred to six hundred and four hundred, down as low as that. There have been investigations carried on along these lines that I don't know whether they have been published or not, and that has been shown conclusively to be the case.

There is another point regarding the use of oil that was brought up in one of our recent meetings in New York, and by a speaker who has done considerable investigating with the different quenching oils, and he made the statement, which is rather a broad statement "that he didn't care what kind of oil it was that was used as a quenching medium; that he could get good results with that bath if the temperature was kept uniform," and I believe that to be absolutely true. Of course the question of deterioration of the oil is another one. If you have an oil that breaks down it is uneconomically used, but starting with a new bath and two different kinds of oil, if the temperature of those baths are kept uniform,

you can obtain results that are very nearly the same, and in the ordinary run of work you cannot tell the difference. I think that that is something that the Steel Treaters should bear in mind, because you hear so many arguments just as the speaker said, about the different patent compounds and oils, etc., that confuse you; of course, in choosing an oil you want an oil that will give you the results in the long run; I am not talking about that at all; we want an oil that will stand up, but I should think that should be borne in mind.

MR. McKILLIPS: I have attended a number of these meetings from time to time, and this is the first that I have ever attended that I have been known to talk. If I were to write a paper on the heat treatment of steels, I would emphasize greatly the matter of oils. I would like to say here I have had years of experience along the line that might interest perhaps some of you, and that before I ever got to using pyrometers we used to use a method of testing or heat treating similar to this: we would take a piece of steel of a given size and weight, made identically the same, heat it and then take a given quantity of water, say a pint of water, and put that pint of water into a vessel; take this piece of steel and drop it into that pint of water; we would take the low temperature quenching water, which we will say is about 70, take the piece of steel out of the fire, drop it into the pint of water, and that would perhaps raise the temperautre up we will say to 120 degrees, showing you a difference of 50 degrees. We used to take that difference—I don't know where they got this rule from; it was a rule figured out by Mr. Hadfield—and multiply it by thirty. That will show us that we had a temperature of 1500 degrees. Well, I worked along that line for a long time until I began to see that that was anything but satisfactory, and I would go off to one furnace to make a test that I knew was considerably higher than the other, and I would get still a higher reading. I couldn't tell for a long time why that was. I am saying this just to bear out the speaker's theory on the high and low temperature of the quenching baths in relation to heat. I will say you can take a piece of steel out of the very same fire that read 1500 degrees, put it into the same quantity of water with a temperature of 90 and instead of getting a difference of fifty you probably wouldn't get but a difference of forty, which would only show you had 1200 degrees of heat, where previously the same fire showed you had 1500 degrees. Well, I thought that over and fought it so until they thought I was on the wrong track in bucking it, and I finally, rather than do that, threw up the job. Finally it came to me "How could I prove that thing wasn't right?" It dawned on me all at once that if I took water at 212 and dropped the piece of steel in there I would show that I had no fire at all. (Laughter). Now that is very true, I think, and it is one of the most important things that we have in the heating of tool steel.

Lots of people tell you about pyrometers and lots of people tell you about furnaces, but we don't spoil a lot of our work. A lot of your trouble is in the quenching. The quenching of the thing means in my estimation quite a lot.

CHAIRMAN: One of the largest steel companies in this country with quite a nice pyrometer outfit is still using that method of measuring temperatures, and relying on it to the extent they accept it in preference to what I consider as good a pyrometer as there is on the market. If there is a difference between them they take the calorimetric readings instead of the pyrometer readings.

MR. BUCKLEY: In regard to water quenching, there is one feature that the steel men don't take into consideration, and that is that you will notice from Mr. Hillman's chart as he starts at 70 and works along until it finally dropped—I have not the figures with me—I don't know just exactly what they were—that he gets the peak at about 100 to 110. Now there is a reason for that. The reason for it is that water at 100 to 110 will absorb heat very much faster than at any other temperature. Now after he drops from 110 down you will notice that he is getting something that will hold it up, because as the water gets hotter it slows down in quenching speed. That is one reason why oil is more even in its action than water.

Now there is another feature. He starts his bath at 100 but he cannot harden but very little steel before he gets up above that. Now he has to have some way in which he can circulate his water and keep it at about that temperature. I just want to say another word in regard to Mr. Hillman's microphotographs. Perhaps some of you will think that they weren't quite as fine as they might be. I made those treatments myself; Mr. Hillman made the microphotographs. It was high speed steel, heated to 2250. We quenched in salt and went through four different ways of doing it. The first one quenched in the salt at 1150 and when the steel got down there cooled in the air. The second one was quenched in salts, then taken out and cooled and then put back into the salts and drawn. The third one was quenched in the salts and then quenched in open oil from 1100. The fourth one was quenched direct into the oil and then drawn back at 1150. There has been some criticism on those microphotographs that they weren't as fine as they might have been. I wasn't doing laboratory work; it went through in the shop production work; consequently it didn't cost us twenty-five or thirty dollars to make them, either.

MR. MERRILL: I would like to say here I have been using my salt bath at a temperature of 93 for a good many years, and I am just as fussy over the temperature as I am over my fire. I have been using that for a number of years.

MEMBER: I don't agree with my friend Hillman on some things. We have had more or less scraps and probably will continue to do so, and at the same time be good friends. There was one article in which he says that mineral oil is all right for small shops. I say No, that the small shop needs the good stuff just as much as the large, if not more so, because he only quenches a piece now and then, and he wants an oil that will remain thin all the time. That is, when I say that, that doesn't increase in viscosity. Mineral oil will absorb moisture from the air. It will deteriorate from being open, but with the compounded oil that he speaks of it is hopeless; that is why the tests were made. The viscosity, or rather, the baume of the oil after we got through with the test was precisely the same as when we started. Now we can get an even Brinnel hardness from 70 with a drop from 430 to 418 up to 250 degrees F. Now the other oils,—there is a reason for the other oils. The vegetable oils from the fact that as soon as we commence to use it you change the nature of the oils, which is caused principally by the fatty acid in the oil that thickens up and the light end evaporates. Consequently, after you have quenched for a short time in those kind of oils, take for instance a

4. L. R. Seidell and G. J. Horvitz, "Physical Qualities of High Chrome Steel," Iron Age, vol. 103, No. 5, Jan. 30, 1919, pp. 291-294.

week's quenching, they will deteriorate very rapidly; even at the same temperatures you will get very much softer work, due to the reason that they oxidize.

MR. HILLMAN: I wish to call Mr. Buckley's attention to the fact that three of the largest manufacturing concerns in Worcester, Mass., are using mineral oils. One of them is a part of the U. S. Steel Corporation. Another is a large chain works, and the third is the Fiat Company. There has been nothing proven against mineral oil. There is no doubt in my mind but what mineral oil undergoes fractional distillation, of course, but there are a lot of the biggest concerns in the country using it.

MR. BUCKLEY: One of the three that have used the other oil claim they never had anything like it. They have gone to mineral oil, but they have five thousand gallons of the other oil saved nevertheless. In another instance of a spring concern they began using the mineral oil, but it thickened up so they couldn't pump it through the pipes at all. Those two instances both occurred in the same city.

STAINLESS STEEL
ITS TREATMENT, PROPERTIES AND APPLICATIONS

W. H. Marble*

(A paper presented at Philadelphia Convention)

"Stainless Steel" is so exploited on account of its peculiar property, when properly hardened and finished, of resisting oxidation and corrosion by the ordinary agents.

It has been stated at various times that its discovery was accidental, whereas a careful search would indicate that two men, working independently, with no knowledge of what the other was doing, actually developed this unique alloy.

In 1911, Mr. Elwood Haynes, of Kokomo, Indiana, made experiments with alloys of iron and chrome, with a view to determining the effects of chromium on the resistance of steel and iron to chemical and atmospheric influences; also its effect on the hardness, elasticity and cutting qualities of steel.

About the same time, or possibly a little later, Mr. Harry Brearley, the eminent metallurgist of Sheffield, England, discovered this alloy while working on armor-piercing projectiles for the Russian Government. At that time, he was investigating powder-erosion. His tests produced a non-erodible alloy which did not scale easily and did not tarnish when exposed to the action of many acids, including fruit acids.

The demand for a non-rusting or non-staining material for knives and other cutting tools or instruments suggested itself as a big field for Stainless, and this probably was one of its first uses. Scientific tests have since proved conclusively that a Stainless blade properly made, hardened and tempered, will take and maintain an edge equal to the best cutlery, with the added asset that it resists rust and stain.

During the late war period, all Stainless supplies in England were appropriated by the Ministry of Munitions. The bulk of this material was used for a purpose similar to that for which it was designed—exhaust valves for aero engines, which are required to be strong and resist erosion at high temperatures. Its subsequent use in this country naturally fol-

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lowed, and it has been used successfully, and in large quantities, in place of high-nickel and high-tungsten steels.

It has been stated too, that Stainless is "one of the indirect results of improvements in the manufacture of carbon-free ferro-alloys."

Previous Investigations

In 1917, Dr. W. H. Hatfield,[1] of Brown-Firth's Research Laboratory, Sheffield, England, published results of tensile and impact tests of a steel containing about .30% carbon and 13% chromium. He has also shown comparisons between air, oil and water quenching, followed by a relatively high temperature tempering. Some of his results have been incorporated in a report submitted to the joint Iron and Steel Committee of the S.A.E.[2] and A.S.T.M. This report also includes a brief discussion of proper methods of working, annealing and finishing Stainless Steel, with a chart showing the results of scaling tests with Stainless, high-speed and other alloy steels.

Messrs. French and Yamauchi, of the United States Bureau of Standards, show, in Chemical and Metallurgical Engineering,[3] some very valuable tables, giving results obtained by varying the quenching and tempering temperatures. Their results would indicate that quenching from about 1,750° F. develops the best combination of strength and ductility, although this does not give the maximum hardness; that ductility as measured by elongation and reduction of area is very low in those samples quenched from 1,850° F. and above; that maximum hardness is generally obtained at about 1,950° F.; that the most rapid change in tensile properties and hardness occurs in tempering between about 800° F. and 1,000° F.

Messrs. Seidell and Horvitz, at the present time with the New York Testing Laboratory, discuss in *Iron Age*,[4] results of experiments carried out to find the relation between hardness and double carbides in solution. These results show that with a quenching temperature of 2,150° F., a maximum hardness is produced; that after suitable drawing treatment under these conditions, tensile strength and ductility are maximum. They also show by means of photomicrographs that with minor exceptions, the micro constituents of Stainless Steel are analogous to those with which we are familiar in ordinary carbon steel.

Mr. Elwood Haynes, in an address before the Engineers' Society of Western Pennsylvania, November 25, 1919, draws these conclusions as a result of tests made during the past several years:

That an excess of 8% chromium makes the alloys practically immune to nitric acid; that these alloys could be hardened by heating to redness and quenching; that they are distinctly malleable; that the alloy was much more easily worked if the carbon content were kept below 1%. He also states that its immunity to acids is due primarily to its composition; that, although quenching in water enhanced its resistance to a considerable degree, it is best to use oil for quenching, in order to avoid local contractions and stress in the finished product. His tests have shown that air-cooled forgings show a remarkably fine grain and good cutting qualities,

1. W. H. Hatfield, "Heat Treatment of Aircraft Steels," Automobile Engineer, 1917, vol. 7.

2. Journal of the Society of Automotive Engineers, vol. 5, No. 3, September, 1919, pp. 262 and 263.

3. H. J. French and Yoshito Yamauchi, "Heat Treatment of a High-Chromium Steel," Chemical and Metallurgical Engineering, vol. 23, No. 1, July 7, 1920.

depending upon the exact composition and the highest temperature up to which it was heated before hammering, and that, notwithstanding the comparatively high temperatures of working this steel, the bars show almost no scale during the forging operation. By increasing the carbon content of these alloys, they can be rendered sufficiently hard by quenching to scratch glass. Small castings can be made by the use of chill molds.

Chemical Composition

The selection of a standard analysis has been the result of countless tests that showed generally that, within certain limits, stainlessness is increased with the increase of chromium and the decrease in carbon content.

Carbon	.20 to .40%
Chromium	11.40 to 14%
Manganese	not to exceed .50%
Silicon	not to exceed .30%
Sulphur and Phosphorus	as low as possible.

The question of increasing the carbon point, as well as the effects of a higher silicon content, have been rather exhaustively investigated, but with no subsequent change, for the present, from the foregoing analysis.

A brief resumé of the effects of certain elements upon the various properties of the alloy may be of interest.

Effects of Various Elements

Carbon.—The carbon content usually found in Stainless Steel is .25 to .40%. Under .25% the steel will not harden successfully, while above .40% it is difficult to forge and begins to lose its non-corrosive property. Properly hardened Stainless of correct composition is a martensitic structure with numerous globules of double carbides of iron and chrome present. The steel varies in hardness in direct proportion to its carbon content.

Chromium.—Chrome is the most important element and is practically the only alloy used. It is from the chrome content that Stainless derives its resistance to the various oxides and corrosive agents. Chrome forms carbides with the carbon, which compound not only furnishes the requisite hardening properties, but is in itself one of the most difficult substances known to oxide or corrode. Pure iron is also known to show great resistance to acids and oxidizing conditions, and as hardened Stainless is theoretically a matrix of iron containing chrome carbides, the combination furnishes an alloy which is highly resistant to stain or rust.

Silicon.—Silicon neutralizes the hardening effect of carbon, thereby making possible the use of a much higher carbon content. It has a tendency to remove gaseous impurities and oxides which assists in the formation of a sounder steel mass, free from slag, seams and blow-holes. To offset these desirable properties, however, the silicon retards hardening and increases brittleness. Stainless containing high-silicon cannot be hardened to the same extent as can the same steel without it. It is best then, to keep the silicon content low.

Sulphur and Phosphorus.—Sulphur and phosphorus are injurious in that they assist in the formation of an electrolytic action which induces corrosion. They also have a tendency to segregate. These elements are impurities and should be kept as low as possible.

Manganese.—Manganese counteracts the injurious effects of sulphur by forming sulphides in which formation sulphur does not show a marked tendency towards "red shortness." The manganese content should be kept

low, although a small percentage is necessary to assist in hardening.

Other elements such as nickel, copper, cobalt and tungsten have been used in Stainless Steel, but it is doubtful as to whether any great benefits have been derived from their use. The addition of tungsten and nickel so far as it is known, serve only to increase the luster of the polished section.

Manufacturing

The manufacture of Stainless Steel is in a general way very similar to that of high-speed steel. It is melted in two general types of furnaces, known as the Crucible and Electric, the process of operation and construction of which are no doubt familiar to everyone. The steps leading up to the actual heat treatment can be stated briefly.

After the ingots have been cast and allowed to cool somewhat, they are "box annealed" at a temperature as near 1,380° F. as possible, for a period of about 13 hours. They are then allowed to cool slowly to atmospheric temperature. This is most important, for Stainless, like high-speed steel, is air-hardening. Ingots before forgings are usually planed to remove all surface defects. The material will machine very easily after the annealing operation.

Forging and Rolling

Before forging the ingot should be heated slowly up to a temperature of from 1,650° F. to 2,100° F. It should be cogged down by easy stages, care being taken that the temperature does not fall below 1,650° F. If the steel is worked below these temperatures, it is liable to be ruptured or broken under the heavy blows of the hammer. A noticeable feature of this operation is the very inappreciable amount of scale formed. The steel will be hard if allowed to cool in the air after forging, the hardness depending upon the exact composition of the material and the highest temperature up to which it was heated before being finally hammered. This hardness may vary over wide limits—to correspond with a Brinell hardness of 500 if the temperature before hammering was as low as 1,800° F., or to a Brinell hardness of only 250 if the temperature before hammering had reached 2,000°F.

Annealing

One of the characteristics of this steel is that if heated to a temperature of 1,800° F. and allowed to cool quickly, it becomes hardened. Consequently, after forging it must be annealed before it can be machined. Stainless Steel should be annealed about the same as high-grade tool steel, except that the heat should be about 1,400° F. A good way is to heat the steel in pipes, and cool pipe and steel very slowly in a pit, or to heat it up to about 1,400° F. in an open furnace, then close up the furnace and allow the steel to remain there while the temperature drops slowly to 1,100° F. Then take the steel out and allow it to cool naturally in the air. After annealing, it will have a hardness of approximately 200 Brinell and machines easily. Should a softer condition be required, heat to 1,560° F. or 1,600° F., and follow by very slow cooling.

Hardening

This material may be hardened in air, oil or water. A good hardening temperature is somewhere in the vicinity of 1,750° F., quenching in oil or water, or cooling in the air depending on the size or shape of piece treated. The steel should be tempered back to suit the work or results desired as

with any other alloy steel. If the higher hardening temperature is chosen, it will require a correspondingly lower tempering temperature—the reverse of a carbon steel.

Temper Colors

Temper colors appear at approximately twice the temperature of ordinary carbon steels, for the higher heats, so that the temper should be drawn to a definite temperature in a bath or furnace instead of drawing to a color. A good tempering temperature for a knife blade is about 280° F. to 300° F., but for a valve it would be necessary to go as high as 1,100° F. These colors are due to very thin films of oxidized metal. As Stainless Steel resists oxidizing, it requires more heat to produce a given color than ordinary tool steel, as is illustrated by the following table, the temperatures of which are only approximate.

Color	Appears on Stainless Steel (Degrees Fahrenheit)	Appears on Tool Steel (Degrees Fahrenheit)
Faint Yellow	....	430
Light Straw	575	450
Dark Straw	660	475
Purple (Reddish)	750	525
Purple (Bluish)	850	550
Blue	1,000	575
Gray Blue	1,100	600
Greenish Blue	1,300	625

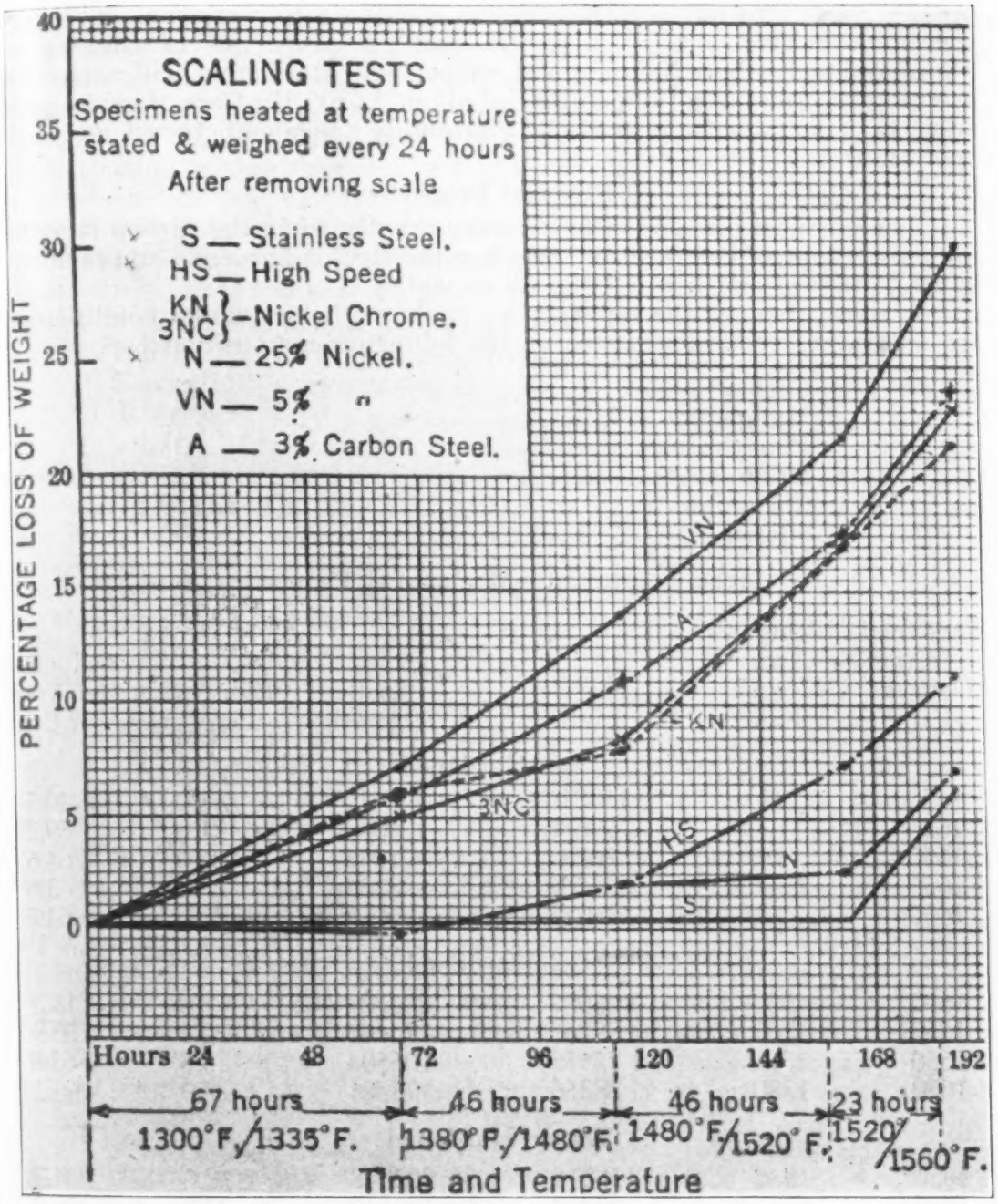
Scaling

As the temperature of ordinary steel rises, the surface oxidizes into a scale of measurable thickness and even at a low red heat, the thickness of the scale increases with time. Stainless Steel behaves quite differently. Up to a temperature of about 1,520° F., the gloss surface due to polishing and hot tinting is permanent, and the specimen neither gains nor loses appreciably in weight. Its comparative value in this respect is illustrated by the following chart which records the percentage lost in weight of various steels after exposure for many hours at temperatures above red heat.

Corrosion

The steel's power to resist stain does not reside in any finish which may be applied by the manufacturer, but in the hardened steel itself. However, rough the surface of a hardened, hardened and tempered article may be, if it is a clean metallic surface and has not been distorted, it will be rustless. However, to exercise this feature to the best advantage, a really good ground polished surface should be provided. Where the highest possible degree of resistance to corrosion is essential, it is recommended that the parts be drawn back very slightly after hardening, and that they then be polished free from scale marks, hair lines or other surface imperfections. These imperfections if left, serve as nuclei from which corrosion is apt to spread. This process is essential only where the bright color of the polished metal is desired to be permanent.

Stainless Steel does not corrode when in contact with other steel. It is, however, attacked in an otherwise non-corroding liquid when in direct metallic contact with copper or copper alloys, such as gunmetal.



Etching.—A mixture of nitric and hydrochloric acid will etch Stainless Steel; hydrochloric acid alone in which copper sulphate has been dissolved, serves very well for light etching. The use of a mixture of nitric and hydrochloric acids might create fumes which are objectionable, in which case it is good commercial practice to use a saturated solution of ferric chloride in hydrochloric acid. Another etching solution consists of two parts of 50% solution of hydrochloric acid; two parts of 15% solution of Ammonium persulphate, and one part of a concentrated alcoholic solution of o-nitro-phenol.

Cold Working

Cold working of Stainless Steel destroys its stainless property, and

unless it is heat-treated subsequently to restore it, it is useless to put cold-pressed parts into use necessitating its resistance to corrosion. The heat-treatment necessary to restore the stainless properties of cold-worked Stainless Steel is by hardening and tempering. Hardening will necessitate bringing the steel to a temperature of about 1,650° F. Care should also be taken that the material or parts be thoroughly annealed between successive operations.

Physical Properties

The physical properties do not vary greatly when the carbon is within the usual range of composition, or when the steel is hardened and tempered in air, hardened and tempered in oil or water.

A comparison of these properties is shown below, under conditions of air, oil and water-hardened steel of the following composition:

Carbon	.240
Manganese	.300
Phosphorus	.035
Sulphur	.035
Chromium	12.850
Silicon	.200

Heat Treatment—Mechanical Properties

Hardened from Degrees Fahr.	Tempered at Degrees Fahr.	Elastic Limit	Tensile Strength	Elongation Per Cent	Reduction of Area Per Cent
		Air Hardened			
1650	930	158816	192416	13.0	40.5
1650	1100	99680	120064	21.0	59.2
1650	1300	70784	101248	26.0	64.6
1650	1380	66080	98336	28.0	63.6
1650	1470	70784	96992	27.0	64.7
		Oil Hardened			
1650	930	163072	202720	8.0	18.2
1650	1100	88256	116480	20.0	56.9
1650	1300	77952	105504	25.5	63.8
1650	1380	88256	98784	27.0	66.3
		Water Hardened			
1650	830	158816	202048	12.0	34.2
1650	1100	90272	120736	22.0	59.8
1650	1300	66080	102592	25.8	64.7
1650	1380	67200	97888	27.0	65.2

(The above tests were drawn for one hour at the noted temperatures and allowed to cool in air).

This steel has a co-efficient of expansion of .00001091512, which is slightly less than ordinary steel.

Applications

Cutlery.—Knives made of this steel are in all respects quite equal to those made of the best qualities of cast steel, besides having the advantage

of being stainless. The composition of about 13% chromium and .30% carbon is used. Dr. W. H. Hatfield[5] is authority for the statements that Stainless Steel could be hardened far in excess of actual requirements for table knives, carvers, pocket-knives and razors. To get such results, the steel should be hardened from temperatures of 1,740° F. to 1,830° F., or about 250° F. to 300° F. higher than the usual temperatures necessary in the hardening of high-carbon cast steels. Successful tempering can be accomplished by placing the knives in an oil bath for 5 minutes, the oil of which is maintained at a temperature of about 355° F.

Valves.—Valves have been generally made to meet the following specifications, in the annealed condition:

Yield Point, pounds per square inch	70,000
Tensile Strength, pounds per square inch	90,000
Elongation in two inches	18%
Reduction of Area	50%

The usual heat treatment is to quench in oil from 1,650° F. and temper or draw at 1,100° F. to 1,200° F. One manufacturer hardens valves by heating the previously annealed valves to 1,650° F. and cooling in air. This gives a Scleroscope hardness of about 50. Should a greater degree of hardness be desired it can be obtained by heating to 2,000° F., cooling in air. This gives a Scleroscope hardness of about 75.

Besides its use for cutlery and valves, the purposes to which Stainless can be applied are legion. The fact that nickel steels containing a high percentage of nickel, are difficult to machine, opens up a large field for Stainless, in that it can be readily softened for machining purposes and afterwards suitably hardened to resist wear and stress. As this material is very difficult to deform, and is not easily eroded at temperatures up to 1,500° F., it is an excellent material for the manufacture of hot dies, extrusion dies, punches and moles for die castings.

Other engineering applications of the alloy may be mentioned—turbine blades, pump rods and valves, acid pumps, rams, evaporating pans, races and rollers for ball bearings, refrigerator machinery. Several instances might be cited where turbine and pump parts have maintained their bright appearance, with a very inappreciable amount of corrosion, after having been in use for several years. Due to the extreme toughness, ability to resist abrasian, and its mirror-like finish, moving parts made of this alloy wear longer, and, due to the reduced amount of friction, require less repacking. Since the steel is affected only slightly by salt water or salt air, it may be employed for a variety of marine purposes.

In the electrical field, Stainless Steel is used for permanent magnets and for electric cooking stoves and utensils, where the advantages of permanently bright and clean surfaces in assisting the reflection of heat and consequent economy of current are immediately apparent.

CONCLUSION

This steel is costly to produce in the form of cutlery by reason of the necessity for better grinding and more careful forging in consequence of its great hardness. For general use, it may be said that it is costly to manufacture by reason of the expensive alloy employed, and the comparatively heavy waste (due to scrap) involved as a result of very careful inspection; but there *is* a very wide field of usefulness before it.

5. Dr. W. H. Hatfield, "Cutlery—Stainless and Otherwise," December 17, 1919, reviewed in the American Cutler, June, 1919.

DISCUSSION OF MR. MARBLE'S PAPER

Chairman: Mr. Marble informs me that Dr. Johnson will reply to any discussion along these lines, so you will now have another opportunity to discuss this same subject as was first presented, as well as the points that Mr. Marble brought out. We now have ten minutes for discussion.

Mr. Hupp: I would like to ask Dr. Johnson what has been the results of experiments in treating the acid-resisting cutlery in a solution of sulphuric acid around a temperature of boiling water?

Dr. Johnson: All the value of acid resisting is secured at low temperatures. That is, you are speaking now of the first paper I take it. I would say that the stainless steel is not much in resistance to sulphuric acid. None of that type of steels are. But the other type I mentioned offers very considerable resistance at low temperatures, but if you apply heat then your resistance begins to fall down very rapidly. The value of low temperatures for resistance is well known; if you have something you are not intending to apply heat to it comes in very promisingly there. If you apply heat the resistance begins to break down.

Mr. S. J. Sharpe: I would like to ask Dr. Johnson if this steel would be suitable for etching on such as textile work?

Dr. Johnson: The other type of acid resisting, flame resisting, and non-magnetic offers very considerable resistance at ordinary temperature.

Mr. Sharpe: Would you consider this a good grade of steel for manufacturing mills of that purpose? It is etching with sulphuric acid.

Dr. Johnson: The stainless steel will etch all right, but the flame and acid resisting will not etch with sulphuric.

Mr. Sharpe: It would stand up, though. We use now about a .40 carbon steel for these mills. We have quite frequently a break-down on the surface after having the pattern for the mill all etched. Maybe we will use it about fifteen or twenty minutes and one spot will break down. Now whether or not this stainless steel would stand up after tempering or case hardening better than the average .40 carbon steel is what I want to get an answer to. After you have etched the pattern on it and hardened.

Dr. Johnson: I would say, yes.

Mr. D'Arcambal: During the war we used stainless steel valves for the Hispano-Suiza Motor, and we found by heating the valves up to 2100 and quenching in oil at 1400 we got very good results.

Dr. Johnson: That would be all right up to two thousand Fahrenheit; I would say it is perfectly safe for stainless steel at that temperature. In the first paper we showed photographs of stainless steel breaking down up above two thousand degrees. It is perfectly safe, however, up to that point I would say.

Mr. DeVrees: The last speaker has mentioned double carbide chromium, in the .30 carbon, .13 chromium stainless steel. Now I must confess that I don't believe he knows anything about that, but I would like to ask him if he has isolated those carbides? If he really has done it it would be extremely interesting, because it seems to me that when you have free carbides in a mass of material that those are going to be electro-positive or electro-negative to the surrounding ground mass of the steel, and would, naturally, when you put electrolite like sulphuric or nitric acid or salt water on there, form rapid points of attack. Now if he has any information on that I would be very glad to hear it, because it has been

stated there are no microscopically detectable free carbides in that kind of steel. If he has some later information I would like to have it.

Dr. Johnson: I would say that I will give no opinion one way or the other, because I have made no attempt to separate these. In fact, I don't know whether Mr. Marble has any information on that or not, but that is my remark. Now whatever Mr. Marble may say on that is up to him.

Mr. Marble: I think I can show the gentleman my authorities. I have authorities for my statement. Mr. Seibel of the New York Testing Laboratory is one.

Member: I may mention in that connection that I was at the New York Chapter meeting when Don Clark, I believe it was, read a paper along very much the same lines as the last speaker, and I brought up the same question, but I got no information. This is not a question that I am asking for any reason except it seems to me that it is very interesting in connection with the rusting and the staining of the steel. If we get a lot of free carbides there it is evident they are going to be either electro-positive or electro-negative to the surrounding ground mass, and since the speaker said there were double carbides of chromium there, which I very much doubt myself, because there is only .30 carbon in the steel, and with that in the steel it is very evident to every metallurgist you cannot get much of the cromium to unite with the carbon. It is almost self-evident that although cromium in itself is an element that goes with the carbon in the steel and likes to form carbides when it has a chance, it is not going to have much of a chance when there is only .30 carbon there to form it with.

Dr. Johnson: As I said before, I have made no tests on this and can only give a supposition, and I am free to say I wouldn't be surprised if you defined those carbides, but it is only a supposition. In the structure shown in the picture it would perhaps show an indication of carbides.

DISCUSSION OF MR. TROUT'S PAPER

Published Vol. I, No. 1. Page 51.

MR. COX: Would the producer gas installation be economical for a consumption of about three million cubic feet of gas a month?

MR. TROUT: You have got to get that down to terms of the hour—it would be about a thousand feet an hour?

MR. COX: It would be about 1,000 feet per hour for each furnace, and we have ten of them.

MR. TROUT: There is an economic condition there. You could produce your gas with an over-all cost of about 47 to 50 cents.

MEMBER: You have cited several tests against oil, and if I am correct you gave the B. T. U. input considerably in favor of gas in each case. Am I correct in that?

MR. TROUT: Yes.

MEMBER: Now in your paper you made the statement that the flame temperature of oil was considerably greater than producer gas.

MR. TROUT: I didn't say that. I said that on account of the high temperatures it is easier of application, referring to oil.

MEMBER: That being the case, assuming, for instance, that the oil has a higher temperature, how do you account for the difference in the B. T. U. input?

MR. TROUT: It seems to follow that a gaseous fuel is more efficiently applied to a furnace than a solid fuel.

MEMBER: That being the case, now is it a case of application more than it is a case of the fuel used?

MR. TROUT: Admitted.

MEMBER: That was the point I wanted to make, that it wasn't the fuel but the application. Now in the test you made you mentioned the fuel going in and what came out, but did you know that your oil fire was not excessively over-ventilated and that you were losing your heat through over-ventilation?

MR. TROUT: These tests were made by the engineers of the automobile plant and sent in to us. They were supposed to have been made with all care taken of that. I will be glad to show you a copy of it.

MEMBER: Now I am not boosting any particular fuel. We are a firm of hoisting engineers. The point is so often made that there is an economy in a particular fuel, and our experience is that there is no particular economy in any particular fuel except as caused by local conditions in the price of the fuel. Seventy-five per cent of the cause of fuel economy lies in the application to the individual plant.

MR. TROUT: There is some difference due to heat liberated through different processes of application. It may be possible to apply oil through some of the newer types of burners and methods of gasifying that oil before entering the furnace that would give you as high efficiency B. T. U. for B. T. U. as we now get with gas applications, but with the ordinary application in the many plants that we visit that is not the case.

MEMBER: I know you are correct in that statement, but it would seem to me from my observation, and I have followed this game for possibly twenty years now, that as far as a matter of application to the plant in steam boiler work is concerned, we can secure a greater over-all efficiency with oil than we secure with any other fuel. I am not boosting oil, either, but we get the highest over-all efficiency with oil that we do with any fuel. We get it because we have a good application.

MR. TROUT: Maybe you have not applied the other fuel as efficiently as you do the oil.

MR. YOULE: That is entirely possible, but we get our efficiency in oil from flame temperature in that case.

MR. TROUT: I don't think that would be true in the case of the paper under discussion with heat treating furnaces.

MR. YOULE: Oh, no, I didn't mean to give that impression.

MR. ROCKWELL: I would like to ask how you take care in a small producer plant without a gas set?

MR. TROUT: The construction of the plant is such that the gas exhauster which is used in connection with bituminous coal or on anthracite where the gas is used for fuel purposes, there is a gas exhauster installed in each plant and that is either changed in speed by automatic control through pressure in the distributing line or else there is a by-pass around the exhauster which automatically maintains a uniform pressure in the distributing line.

MR. ROCKWELL: How does it affect the chemical properties of the gas? Supposing there was a variation in flow throughout the plant.

MR. TROUT: Practically not at all, that is, within commercial limits.

VARIOUS QUENCHING MEDIUMS AND THEIR APPLICATION

By W. G. Lottes*

(A Paper presented at Philadelphia Convention)

I wish some of the members of the committee would tell me why they asked me to read a paper on quenching medium for the heat treatment of steel. I know there are hundreds of members of this organization that are more competent than I am to read a paper on this subject. I am afraid that some of the college bred members have put up a job, as they do enjoy picking on a Freshman.

Whatever their object was, I want to tell you that it was among the proudest hours of my life when I received the invitation to prepare a paper for this, our Second National Convention, on the treatment of the most indispensable metal on the earth's surface. With it we have conquered the beast and the monarch. We have protected ourselves and our country with the pioneer's coming, the ring of the anvil, followed by the sickle that cuts the ripened grain and many other labor saving devices.

The subject of quenching medium for the heat treatment of steel is entitled to more consideration than it has received in the past, especially within the last ten years when we made greater progress than we have in any ten years previous.

First, I want to say opinions on this subject vary, similar to religious and political opinion, and some are just as unreasonable.

We have had patent quenching mediums on the market besides the many secret mixtures and the many different waters used and sold, some from certain springs, rivers and wells; rain water that fell certain times of the year or Holy Days; rain water that passed through horse barns; muddy rain water, which has some merit in preventing water cracks due to the slower cooling quality.

In the majority of cases when the tool hardener, or whoever did the heat treating, got results quenching in any of these mediums he was very careful not to tell anyone. Very often his employer did not know what he was using, but both had all the confidence in the quenching medium, to the extent that the employer felt that his hardener was one of the indispensable men at his factory. All concerned were of the firm belief that it was the quenching medium that gave them the quality that he was getting. They were just as firm in their belief as people are in their religious belief and today we have some men who make their living selling the quenching medium to the blacksmith by making him believe that it was the only safe thing to use to secure everlasting happiness in connection with the hardening of steel.

These same men are still getting converts, get the same letters of recommendation the patent medicine man gets and unless this organization exposes the many fake compounds and quenching mediums, these men are going to get what the patent medicine man was not able to extract from the people under false pretense.

It is not a difficult matter to test quenching mediums, as you will see on the curves shown on Plate No. 1, page 186.

It is also not a difficult matter to control your quenching medium by different temperatures and circulating speed.

How many of us have really gone into this to the extent that we should know what the effect would be by using water at different tem-

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peratures compared with the special quenching oils.

The use of caustic soda or salt and at a temperature that will cool at the same rate that these oils do, beyond a doubt will give us the same results.

I do not believe there is any doubt in the minds of any experienced steel treater that the rate of cooling from the proper heat controls the hardness.

I am convinced that the rate of cooling from above the transformation point down to about 800 degrees Fahrenheit is what controls the quality of the effect of the heat treatment on all carbon steels.

I am also convinced that a 30-40 carbon steel of the larger area is not an oil hardening steel. We are limited in getting the desired hardness in oils of the larger area on carbon steels.

When quenching in water, we have better control of this by the use of soft water at different temperatures and the use of different percentages of common salt or soda mixed with the water.

For the past two years, I have done some experimenting, using hot water in place of oil; not in laboratory test but in a regular manufacturing proposition. The curve shown in this picture shows the effect of water at different temperatures compared with oil on a two inch diameter with a pyrometer couple fastened in the center. The principal object of this test was to show me the effect of quenching a piece of this area toward the center of the bar.

It is necessary in many cases that our quenching medium should be such that it will effect the steel to a greater depth than is possible to get in oil. The cooling from a heat beyond the transformation point down to about 800 degrees Fahrenheit should be sudden. From here down the rate of cooling is of less importance except for parts that must be very hard, then large uniform areas may be withdrawn from the water at about this temperature and eliminate the drawing operation, at the same time prevent some distortion.

We should figure the cost of heat treatment of steel just as we do any machine operation. In the past in the majority of cases the man who did the tempering very seldom gave the cost any thought. This you can see when you watch some of our tool hardeners for a few hours.

The Harvester Company has a great many different classes of work, in some cases it is not a question of cost as much as it is of quality, while on some of the agricultural implements it would be a waste of time and money to attempt to work to any such limits.

Either in machine operation or the heat treating operation, many machines have been designed with no intention of ever heat treating any parts of it. Until recent years when the larger tractors are used, we find weak parts on some of these machines and a very crude heat treating operation gives us an excess safety factor.

No. 2 shows a test made on 30-40 carbon Bessemer steel "I" beams $1\frac{1}{2}x\frac{9}{16}$", one-half of them were quenched in oil and the other half in water at 175 degrees Fahrenheit, all pieces taken from the same bar. This transverse test was made to determine just what temperature it was necessary to keep the water at.

No. 3 shows transverse test of 30-40 carbon Bessemer taken from different bars.

No. 4 shows the cooling quality of five different grades of oil.

I want to call your attention here that the No. 3 oil, which contains

some degras has given us good results after many months of constant use.

Why it is that we have so little information on the use of hot water for quenching medium and the effect of it on different grades of steel

TABLE No. 2

Heat Treatment of "I" Beam

Cultivator Stock, Section $1\frac{1}{2}'' \times \frac{9}{16}'' \times \frac{9}{32}''$ — .30 — .40 C. Bessemer. Pyrometer reading was 1560° F., Steel 1500° F. Water for quenching was 175° F. There were 16 pieces heated at same time from same bar with regular beams being heat treated; 8 pieces were quenched in water and 8 in oil.

Water Quenched

No. of Piece	Load in Lbs.	Deflection	Permanent Deflection	Brinnell
1	1500	$\frac{7}{32}''$	$\frac{1}{32}''$	
	2000	$\frac{7}{16}''$	$\frac{5}{32}''$	277
2	1500	$\frac{1}{4}''$	$\frac{1}{32}''$	
	2000	$\frac{1}{2}''$	$\frac{7}{32}''$	269
3	1500	$\frac{7}{32}''$	$\frac{1}{32}''$	
	2000	$\frac{1}{2}''$	$\frac{1}{4}''$	223
4	1500	$\frac{1}{4}''$	$\frac{1}{32}''$	
	2000	$\frac{5}{8}''$	$\frac{7}{16}''$	248
5	1500	$\frac{1}{4}''$	$\frac{1}{32}''$	
	2000	$\frac{5}{8}''$	$\frac{7}{16}''$	255
6	1500	$\frac{9}{32}''$	$\frac{1}{8}''$	
	2000	$\frac{5}{8}''$	$\frac{11}{16}''$	228
7	1500	$\frac{7}{32}''$	$\frac{1}{16}''$	
	2000	$\frac{21}{32}''$	$\frac{11}{32}''$	241
8	1500	$\frac{9}{32}''$	$\frac{3}{32}''$	
	2000	$\frac{3}{4}''$	$\frac{1}{2}''$	241
		Average Set at 2000 lbs. $\frac{3}{8}''$		Average 247.75

Oil Quenched

No. of Piece	Load in Lbs.	Deflection	Permanent Deflection	Brinnell
1	1500	$\frac{7}{32}''$	$\frac{1}{32}''$	
	2000	$\frac{19}{32}''$	$\frac{11}{32}''$	241
2	1500	$\frac{1}{4}''$	$\frac{1}{32}''$	
	2000	$\frac{1}{2}''$	$\frac{7}{32}''$	262
3	1500	$\frac{1}{4}''$	$\frac{3}{64}''$	
	2000	$\frac{9}{16}''$	$\frac{5}{16}''$	262
4	1500	$\frac{7}{32}''$	0"	
	1650	$\frac{1}{4}''$	$\frac{1}{32}''$	248
	2000	$\frac{15}{32}''$	$\frac{3}{16}''$	
5	1500	$\frac{3}{16}''$	0"	
	2000	$\frac{11}{32}''$	$\frac{1}{8}''$	255
6	1500	$\frac{7}{32}''$	$\frac{1}{32}''$	
	2000	$\frac{3}{8}''$	$\frac{1}{8}''$	248
7	1500	$\frac{3}{16}''$	0"	
	1650	$\frac{7}{32}''$	$\frac{1}{64}''$	286
	2000	$\frac{3}{8}''$	$\frac{1}{8}''$	
8	1500	$\frac{7}{32}''$	0"	
	1650	$\frac{1}{4}''$	$\frac{1}{32}''$	262
	2000	$\frac{7}{16}''$	$\frac{3}{16}''$	
		Average Set at 2000 lbs. $\frac{5}{32}''$		Average 258

Stock Not Heat Treated

No. of Piece	Load in Lbs.	Deflection	Permanent Deflection	Brinnell
1	1500	$\frac{13}{32}''$	$\frac{5}{8}''$	170
2	1500	$\frac{23}{32}''$	$\frac{11}{32}''$	179

TABLE No. 3

Water Quenched—Cultivator Beams

Water 175° Fah. Steel 1500° Fah.

Size of Stock 1½ x 9/16 I Beam .30 — .40 C. Bessemer

Piece No.	25 lbs.	1000 lbs.	1500 lbs.	1750 lbs.	2000 lbs.	2100 lbs.	2200 lbs.	2250 lbs.	Broke
1	—	1/8	3/32	5/16	3/8	3/8	7/16	7/16	2300
2	5 3/4	5 9/16	5 3/8	5 15/32	5 21/32	SET 1/2	...	...	...
3	5 3/4	5 19/32	5 15/32	5 13/32	5 5/16	SET 3/16	...	...	...
					1899 lbs.				
4	5 23/32	5 19/32	5 1/2	5 13/32	5 9/32	5 1/8	SET 7/32	...	...
5	5 23/32	5 9/16	5 13/32	5 9/32	5 1/8	SET 5/16	...	...	...
6	5 11/16	5 23/64	5 3/8	5 15/64	5 1/8	SET 1/4	...	...	...
					1925 lbs.				
7	5 3/4	5 9/16	5 13/32	5 9/32	5 1/2	SET 5/16	...	...	...
					1875 lbs.				
8	5 11/16	5 1/2	5 3/8	5 17/64	5 1/8	SET 5/16	...	...	...
9	5 3/4	5 9/16	5 7/16	5 11/32	5 3/16	5 1/8	5/16	...	...
10	5 11/16	5 23/64	5 3/8	5 5/16	5 7/16	5 1/8	SET 5/16	...	Broke
					1775 lbs.				
11	5 11/16	5 1/2	5 11/32	5 21/64	5 1/8	SET 5/16	...	...	...
12	5 3/4	5 9/16	5 13/32	5 7/64	5 1/8	SET 1/4	...	...	...
13	5 3/4	5 9/16	5 1/2	5 7/16	5 3/8	5 11/32	5 5/16	5 1/4	SET 1/8
14	5 3/4	5 9/16	5 7/16	5 3/8	5 1/4	5 1/8	SET 5/16	...	...
	Average Weight 1964					Average Set 19/64			

Oil Hardened

Piece No.	25 lbs.	1000 lbs.	1550 lbs.	1750 lbs.	2000 lbs.	2100 lbs.
				1540 lbs.		
1	5 23/32	5 9/16	5 5/16	5 1/8	SET 9/32	—
					1775 lbs.	
2	5 3/4	5 5/8	5 21/64	5 1/4	5 1/8	SET 3/8
				1640 lbs.		
3	5 3/4	5 9/16	5 3/8	5 1/8	SET 3/8	
4	5 3/4	5 5/8	5 1/2	5 3/8	5 1/8	SET 5/16
				1650 lbs.		
5	5 23/32	5 9/16	5 3/8	5 1/8	SET 11/32	
					1830 lbs.	
6	5 3/4	5 19/32	5 15/32	5 9/32	5 1/8	SET 3/8
				1530 lbs.		
7	5 23/32	5 9/16	5 7/32	5 1/8	SET 1/4	
8	5 23/32	5 19/32	5 13/32	5 1/8	SET 11/32	
					1830 lbs.	
9	5 11/16	5 9/16	5 7/16	5 1/4	5 1/8	SET 1/4
						2050 lbs.
10	5 3/4	5 5/8	5 33/64	5 7/16	5 3/16	5 1/8 SET 3/8
11	5 23/32	5 33/64	5 7/16	5 1/8	SET 11/32	
					1850 lbs.	
12	5 3/4	5 5/8	5 1/2	5 5/16	5 1/8	SET 33/64
					2050 lbs.	
13	5 3/4	5 5/8	5 7/16	5 7/32	5 1/2	SET 11/32
					1960 lbs.	
14	5 3/4	33/64	5 1/2	5 3/8	5 1/8	SET 11/32
	Average Weight 1838				Average Set 21/64	

---

must be that some are practicing it and do not care to go in print on the subject because it has not had the approval of the S. A. E.

At our West Pullman Works we have installed an automatic hot water tempering control which has proven a success, shown at "A" in Plate 5. We also use hot water tank shown at "C" in Plate 6, where roller chain parts are hardened. Most of these have been in successful operation for nearly one year. In order to get the desired results, it is necessary to keep the temperature of the water within ten degrees Fahren-

TABLE No. 4

Oils

	No. 1 Per Gal. 58c	No. 2 Per Gal. 43c	No. 3 Per Gal. 20c	No. 4 Per Gal. 29c	No. 5. 25% Fuel Oil
Time required to cool 1½ pounds of steel from 1500° to 300°	154 Sec.	220 Sec.	135 Sec.	160 Sec.	No test run
Time required to cool one pound of steel from 1450° to 300°	155 Sec.	196 Sec.	132 Sec.	195 Sec.	165 Sec.
Time required to cool 1½ pounds of steel from 1450° to 900°	37 Sec.	45 Sec.	38 Sec.	44 Sec.	42 Sec.
Starting temperature of three gallon lot	80 Deg.	80 Deg.	80 Deg.	100 Deg.	80 Deg.
Finish temperature	142 Deg.	165 Deg.	140 Deg.	157 Deg.	162 Deg.

heit. This automatic control keeps it within five, as water will not permit of the same variation in temperature that oil will. We also get better results by circulating the water same as they do with oil by the use of air.

We also found that there is quite a difference in water. At one of our Canadian works, where we use Ontario Lake water, it acted quite different than some of the well water in the central part of Illinois, but we have overcome this variation by the use of caustic soda and a small per cent of common salt.

Plate 7 shows automatic temperature control on gas fired furnace used for the tempering or hardening of steel.

I am very much interested now to hear from members that have experimented or used water at different temperatures.

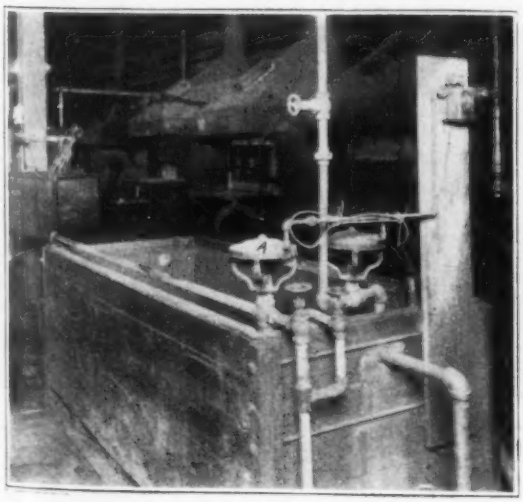


Plate 5

Plate 6

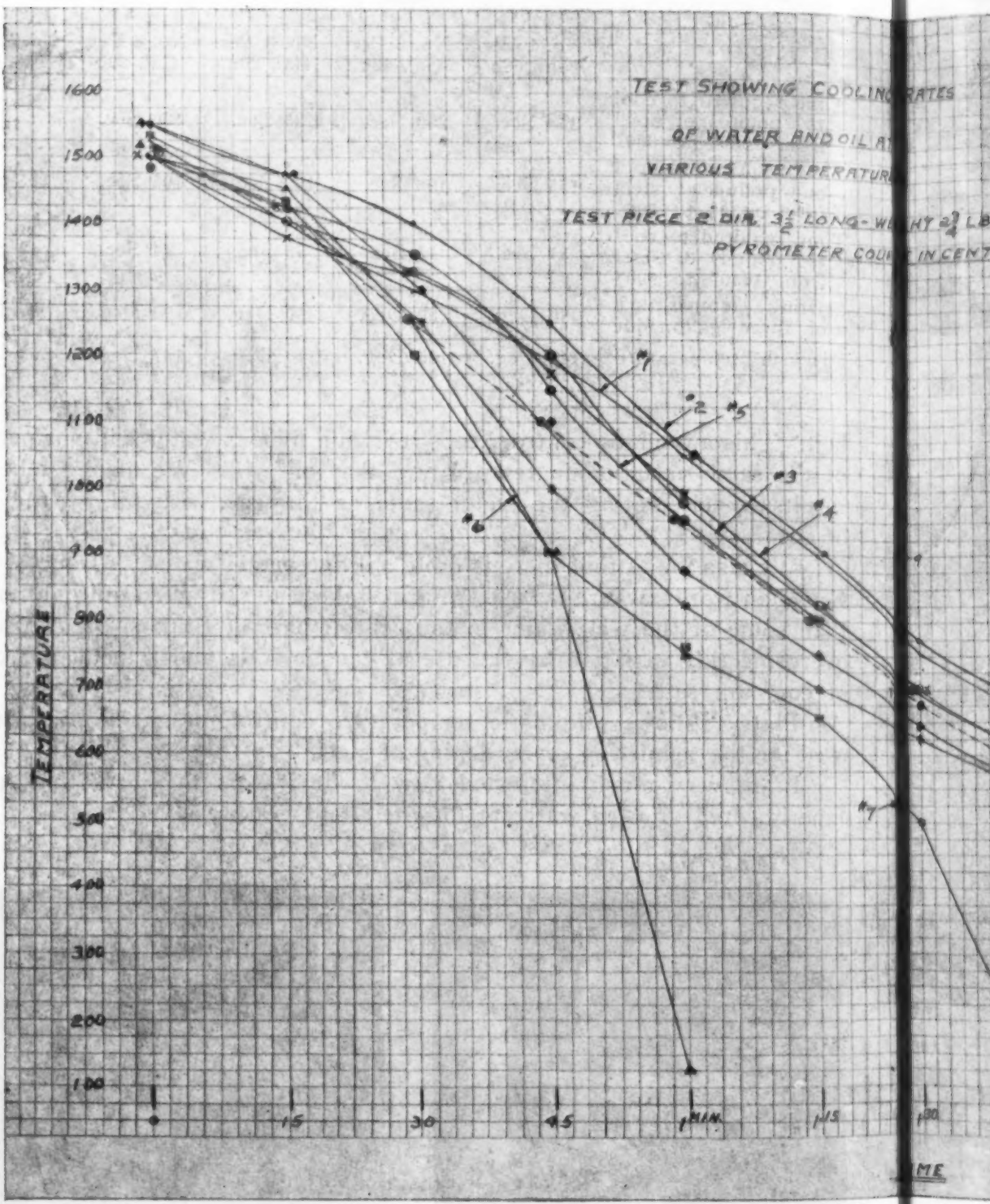
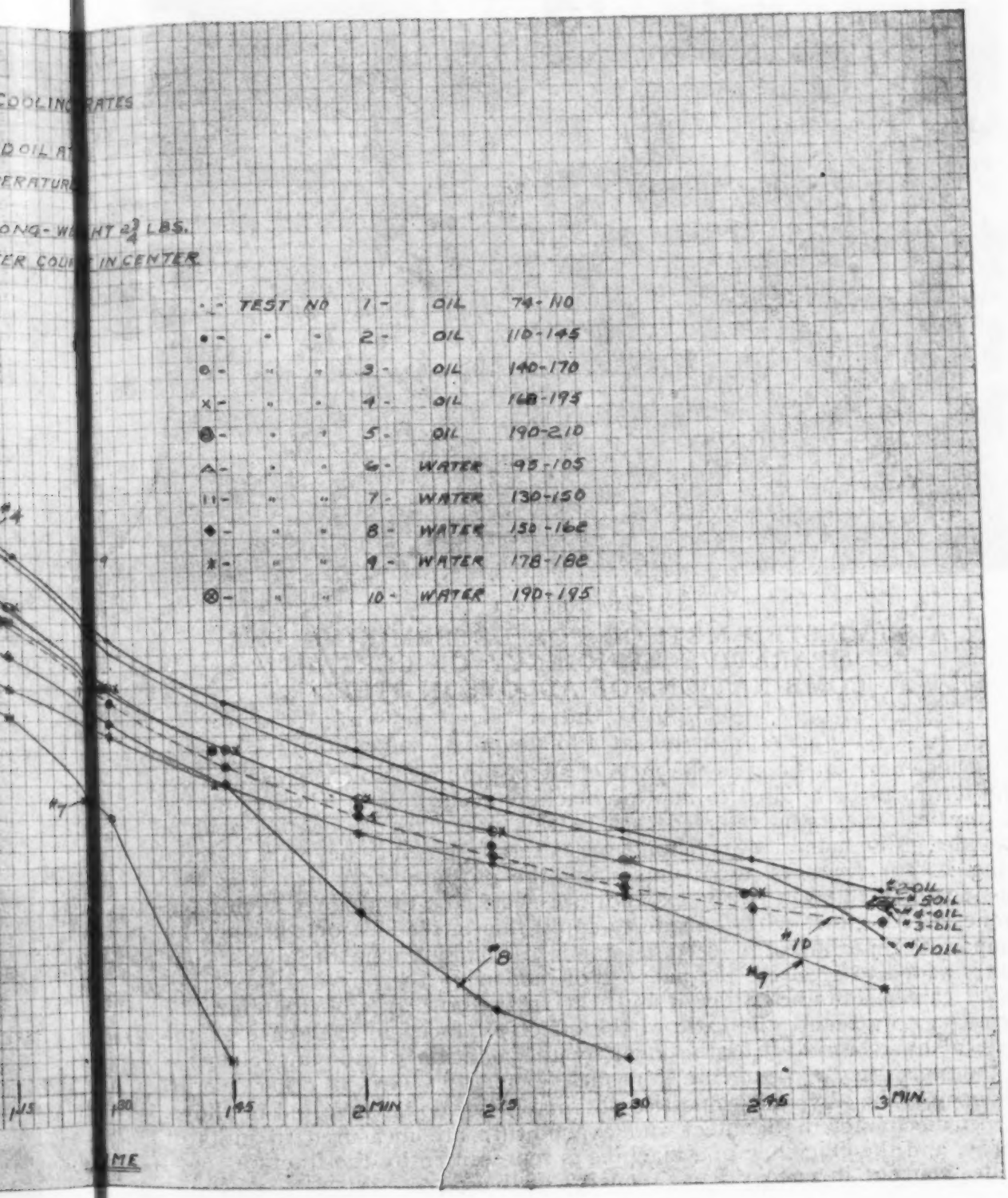


Plate No. 1. Tests Showing Cooling Ra



s Showing Cooling Rates of Water and Oil

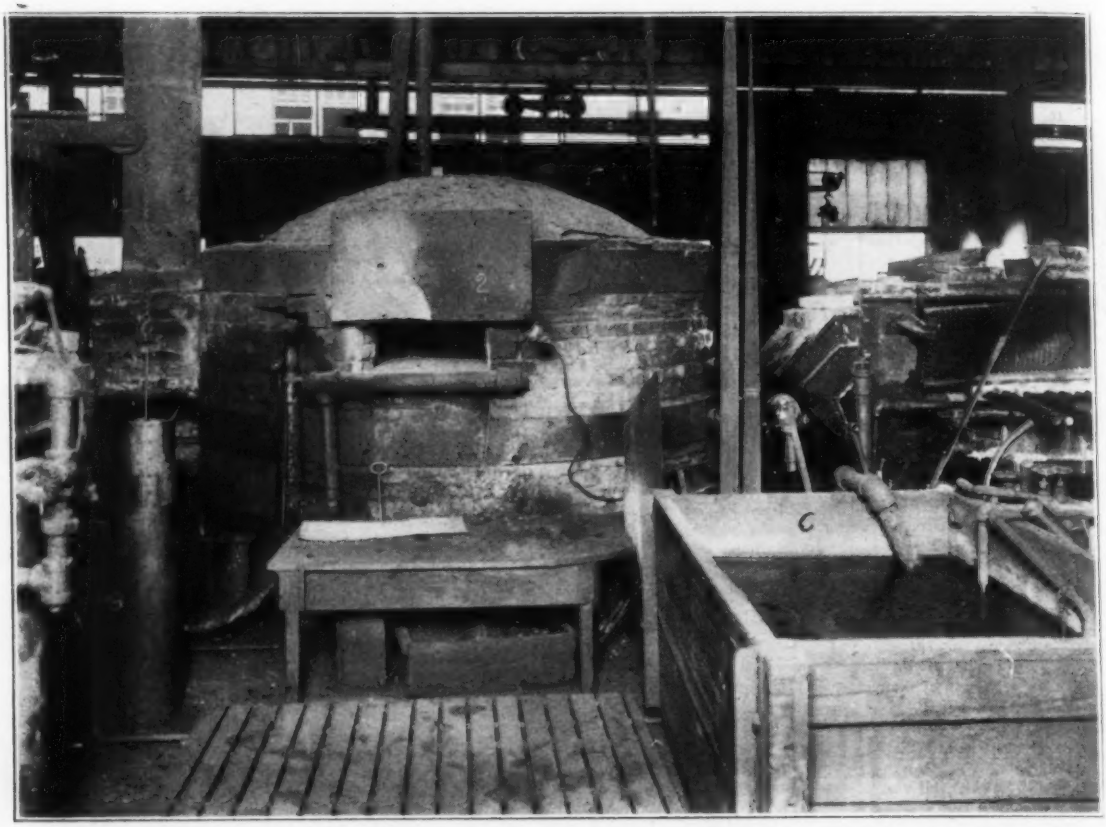


Plate No. 7

A SUGGESTED METHOD FOR DETERMINING THE COMPARATIVE EFFICIENCY OF CERTAIN COMBINATIONS OF ALLOYS IN STEEL

J. D. Cutter*

(A Paper presented at Philadelphia Convention)

Efficiency is defined as the ratio of effect produced to energy expended. The term can be applied to man or machine according to whether mental or physical energy is referred to. In this paper its application will be extended to include man, machine and material, the efficiency of a material being its effectiveness in accomplishing the purpose for which it is used considered in relation to the expenditure necessary to produce such effectiveness. An effort will be made to apply this latter idea of efficiency for comparative purposes to certain standard combinations of alloys commonly added to steel for the purpose of increasing the physical properties which can be obtained from it by heat treatment. It will, therefore, be necessary to measure the ratio of the effect produced in each case on the physical characteristics of the steel by the addition of alloying elements to the necessary expenditure for such elements. Or, in other words, efficiency is the physical properties obtainable per dollar invested in alloys.

In mechanics, both effect and expenditure are measured in units of energy, and the efficiency of a machine is represented by the fraction

$$\frac{\text{output in energy}}{\text{input in energy}} \quad \text{or} \quad \frac{\text{energy delivered}}{\text{energy applied}}$$

the value of which can be mathematically determined and expressed in

*Metallurgist, Climax Molybdenum Co., New York City.

percent. Assuming that a single mathematical expression can be found which will represent the merit possessed by a given steel with respect to the physical properties obtainable from it, and assigning Merit Index as a name for this expression, the equation for the efficiency of the alloys in that steel becomes

$$\text{Equation (1)} \quad \text{Efficiency} = \frac{\text{Merit Index}}{\text{Expenditure for Alloys}}$$

As the units employed in numerator and denominator of this fraction cannot be the same, it will be impossible to express the value thereof in percent. However, a value can be determined which will serve for comparative purposes only.

In order to arrive at a mathematical expression to serve as Merit Index for Equation (1) it will be necessary to limit consideration to tensile physical properties. Elastic Limit and Ultimate Strength are measures of the strength of the material tested while Elongation and Reduction of Area are measures of ductility or toughness. For a given amount of strength that steel is the better which has the greater amount of toughness. Conversely for a given amount of toughness that steel is the better which has the greatest strength. A Merit Index, therefore, should measure combined strength and toughness, should embrace all four of the tensile physical properties and its value should increase or decrease as the value of any one of these properties increases or decreases. An expression which fulfills these requirements follows:

$$\text{Equation (2)} \quad \text{Merit Index} = \frac{\dfrac{\text{E. L.} + \text{U. S.} \times \text{El.}}{2}}{100 \quad -\text{Red.}}$$

in which E.L. and U.S. stand for Elastic Limit and Ultimate Strength, respectively, expressed in thousand pounds per square inch, and El. and Red. stand for Elongation in two inches and Reduction of Area, respectively, expressed in percent.

An additional reason for the employment of the above expression as an Index of Merit is based on the perfectly logical idea that in cases where great strength and also great toughness are required a given material had merit in proportion to the ability of a unit mass thereof to withstand work done upon it and therefore when a test piece is broken, this merit is measured by the work done in breaking the test piece divided by the mass of the material on which this work is done.

Work equals Force times the Distance through which it moves. The force exerted in breaking a standard test piece is proportional to the Mean Breaking Strength. As it would be necessary to have the Stress-Strain diagrams of all tests and to integrate below the stress curve in order to arrive at the exact value of the Mean Breaking Strength in each case, one-half the sum of Elastic Limit and Ultimate Strength has been substituted and is closely equivalent.

The distance through which the breaking force moves is proportioned to the Elongation.

If two test pieces are examined which exhibit widely differing Reductions of Area it will be found that the one showing the smallest reduced area, namely, the one which has necked down the most, will show the least amount of metal which has suffered deformation or upon which

work has been done. In other words, the amount of mass upon which work is done in breaking a tensile test piece may be said to be roughly proportional to the reduced area or to (100 — Red), since if reduced area be expressed in percent, it is equal to (100 — Red).

Hence the Merit Index of Equation (2) is proportional to the work done in breaking the test piece divided by the mass of metal affected by such work as represented by reduced area; and is therefore a fitting index of the ability of a unit mass of the material tested to withstand work done upon it.

If the value of the Merit Index as determined by Equation (2) from a given set of physical properties obtained from tests on a particular alloy steel be divided as per Equation (1) by a figure which represents the relative value of the amounts of alloying elements present, a quantity is derived which represents the relative efficiency of the combination of alloying elements shown by the analysis. Thus without in any way endeavoring to make a comparison of prices of the various grades of alloy steels it is pointed out that by means of a simple calculation, taking into consideration the number of pounds of alloys required per ton of steel and the cost of such alloys, both of which quantities are common knowledge, a definite comparison can be obtained as to the ratio of physical properties obtainable to the cost of the alloys which make such physical properties possible.

By way of illustration, the Merit Index and Comparative Efficiency values of Figures 6 and 7 have been derived from the physical property curves of Figures 1 — 5 for the alloy steels whose analysis are shown in Table 1:

Table 1

	C.	Cr.	Ni.	V.	Mo.
Low Chrome Nickel	.36	.50	1.30		
High Chrome Nickel	.36	1.34	3.40		
3½% Nickel	.35		3.45		
Chrome Vanadium	.35	1.00		.18	
Chrome Molybdenum	.32	.90			.37

The tensile test value of Figures 1 — 5 and the corresponding analyses of Table 1 are averages of tests collected from as many authoritative sources as possible and fairly represent the physical properties which may be expected when sections approximately 1″ round of the several types of steel listed are suitably treated.

The values shown in the figures of this paper are not meant to be taken as absolute, but it is hoped that the method suggested can be used with profit in connection with the data applying in any particular case.

For much of the material from which this paper is composed, I am indebted to Mr. H. T. Chandler of Detroit, Michigan.

DISCUSSION OF MR. CUTTER'S PAPER

Chairman: We will now proceed to discuss the paper just given by Mr. Cutter. I think there are no doubt a great many who are interested in the topic which he discussed, and I hope you will be free to discuss it. We still have fifteen minutes time.

Mr. Lee of Buffalo: I would like to ask Mr. Cutter whether or not his formula has been applied to any other material than steel, and if so, as to what results have been attained.

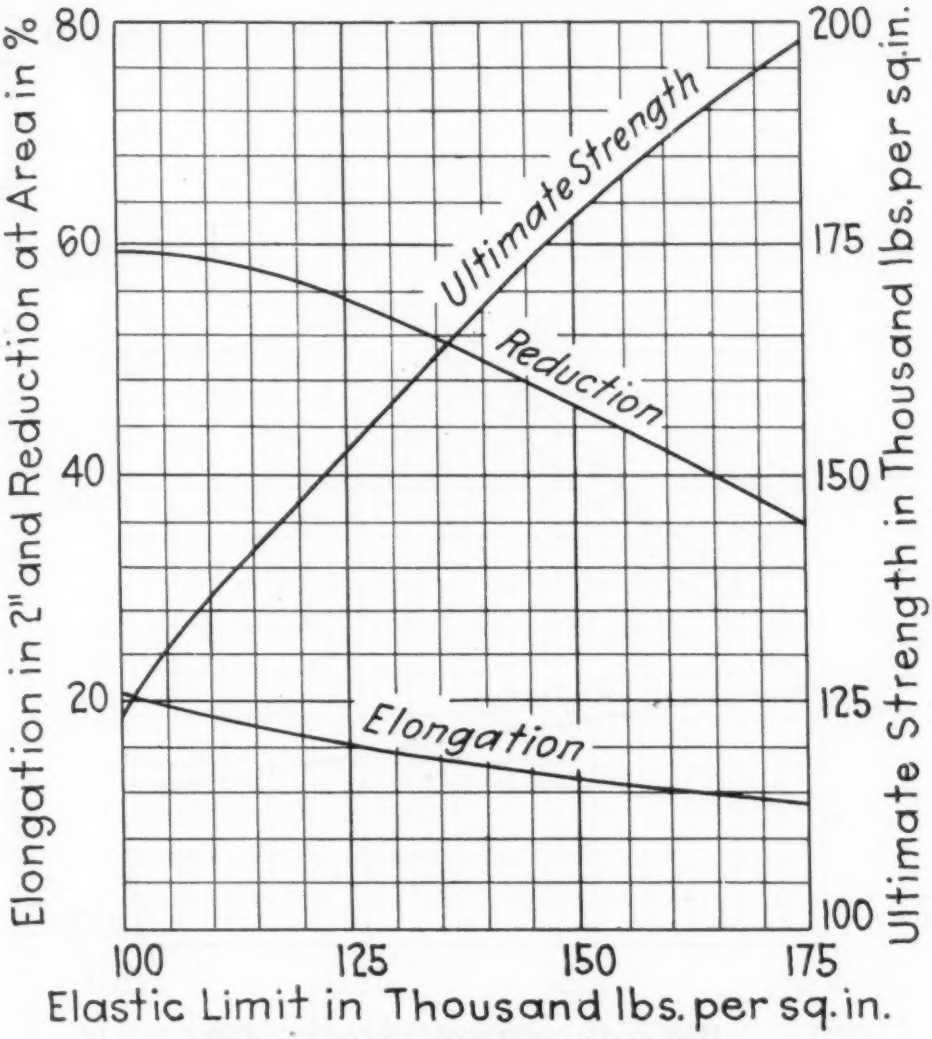


FIG. 1. LOW CHROME NICKEL

Mr. Cutter: I have not applied it to any other material than steel.

Mr. Lee: It seems to me that if the thing could be worked out to apply to malleable iron and cast iron and bronze, etc., which would give a comparative value for the different types used in the different machines, it would be a step in advance.

Mr. Crowe: I would like to ask the speaker what was the highest factor of efficiency that he got on the steel tested that way?

Mr. Cutter: The efficiency Number which I showed on the screen is simply a comparative number. Unless you use exactly the same method of putting in the alloys you would not get the same number. These are not to be taken as an absolute standard by any means. I got one hundred thousand elastic limit with a low chrome nickel steel, and I got an efficiency value of 3.75, and with chrome molybdenum steel slightly higher.

Member: I would like to ask what the cost figures were that were used with the different alloys.

Mr. Cutter: I took the market quotations.

Member: They differ very greatly from the minimum to the maximum.

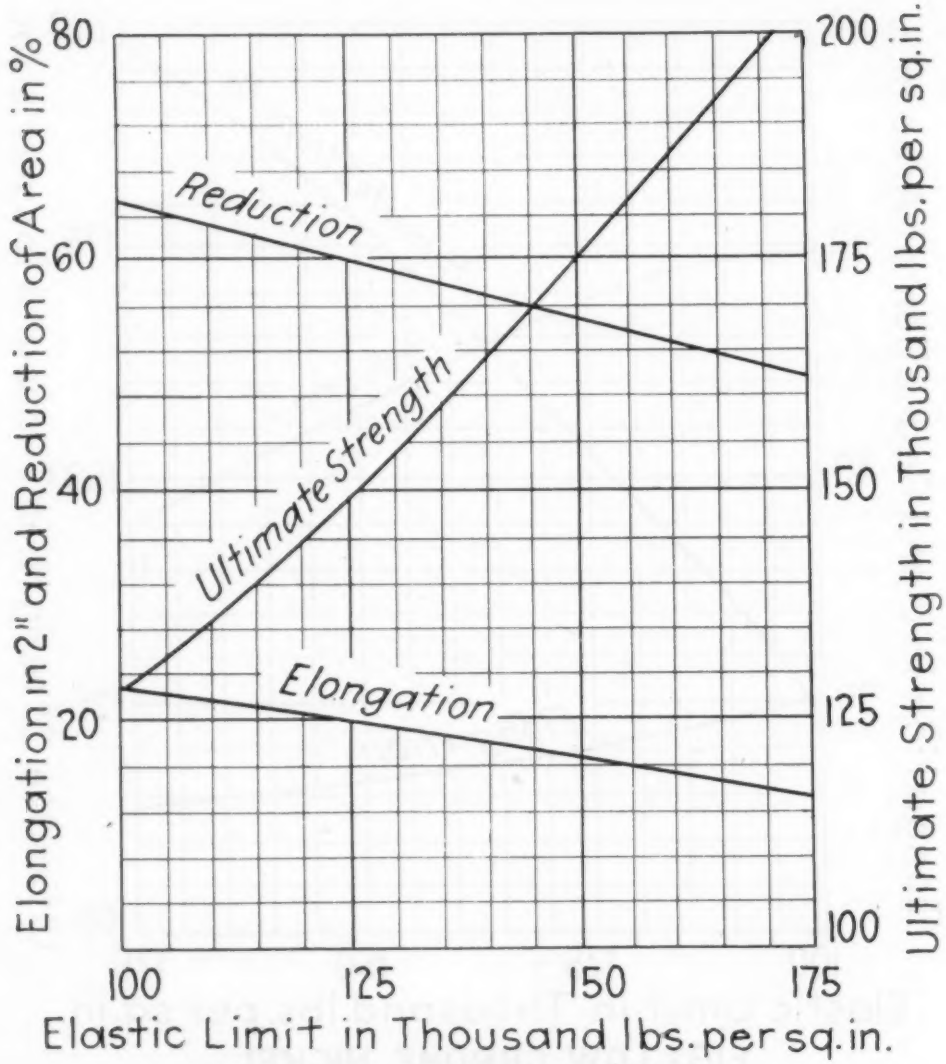


FIG. 2. HIGH CHROME NICKEL

Mr. Cutter: Sure they do. That is why I don't intend that these values should be used as absolutely fixed. They will vary from month to month as the efficiency values gotten by this method will vary also, and might be very different next year.

Member: What I mean is this: the range in price for the different alloys differs greatly. Which do you use, the maximum, the average, the minimum, or what? In the case of molybdenum it varies from $2.00 to $2.50, which do you use?

Mr. Cutter: We used the maximum in that case. Molybdenum is the only one, I believe, that has much discrepancy.

Member: There is that much in vanadium. That ranges from six dollars to ten dollars.

Mr. Cutter: We used seven dollars.

Member: You used too high a price then.

Mr. Cutter: Vanadium is quoted up to nine dollars.

Member: For this class of steel it is high. No one uses nine dollar stuff on the steel you are describing. They use the six dollar or six and one-half.

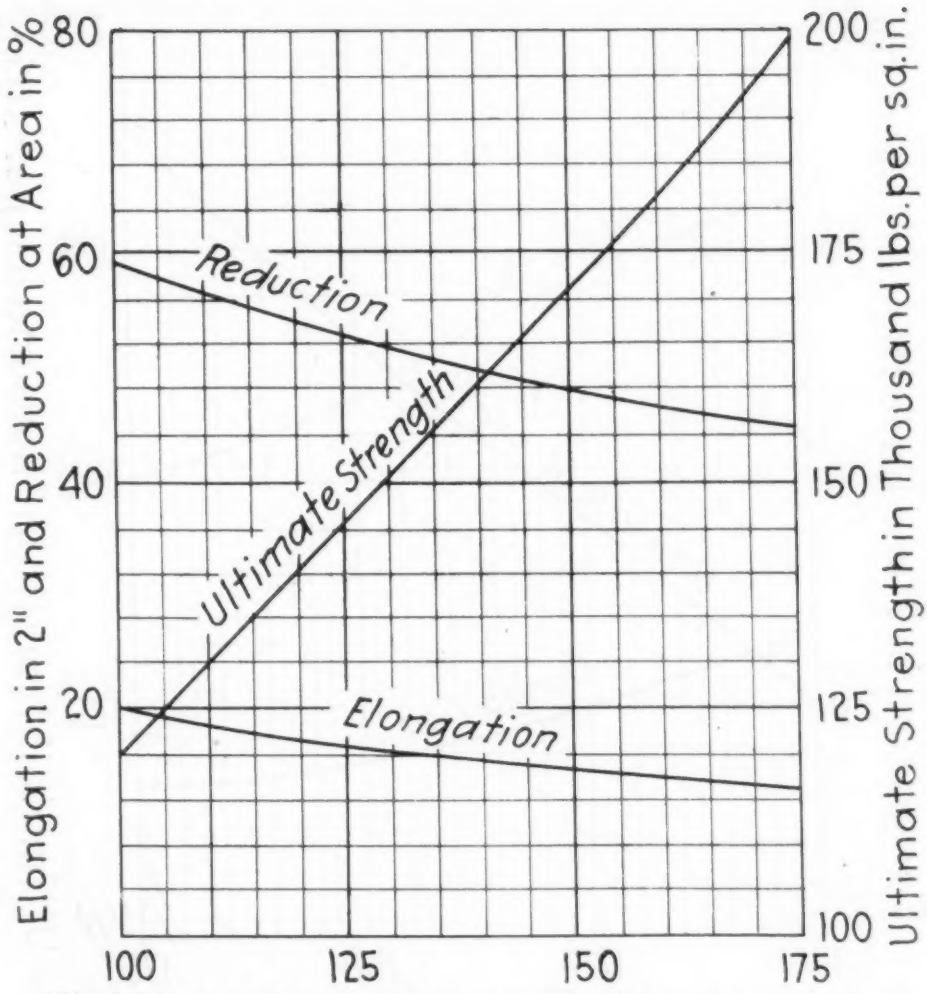


FIG. 3. 3½% NICKEL

Mr. Cutter: I got that quotation from an authoritative source, and I know that their prices vary somewhat. I happened to get that from a large steel company that is paying that much.

Member: Tool steel makers pay a high price; some steel companies are also paying very low prices, and some of them pay very high, so these figures it is necessary to know what the prices are, what the basis is.

Mr. Cutter: As I said in my paper, the method may be applied to the factor applying in any particular case. The charts were shown for the purposes of illustration, and I don't intend they shall be taken as absolutely arbitrary, absolute facts.

Member: The charts ought to show the actual cost on which you based your alloys. Otherwise they are very, very misleading, because without that knowledge no one knows what the prices were that you used, and they are very misleading in that way, because a concern that is using a low priced alloy would be mislead.

Mr. Cutter: I don't thnk they will be misleading at all, because the paper and the purpose of it is stated plainly, sir, and I have used

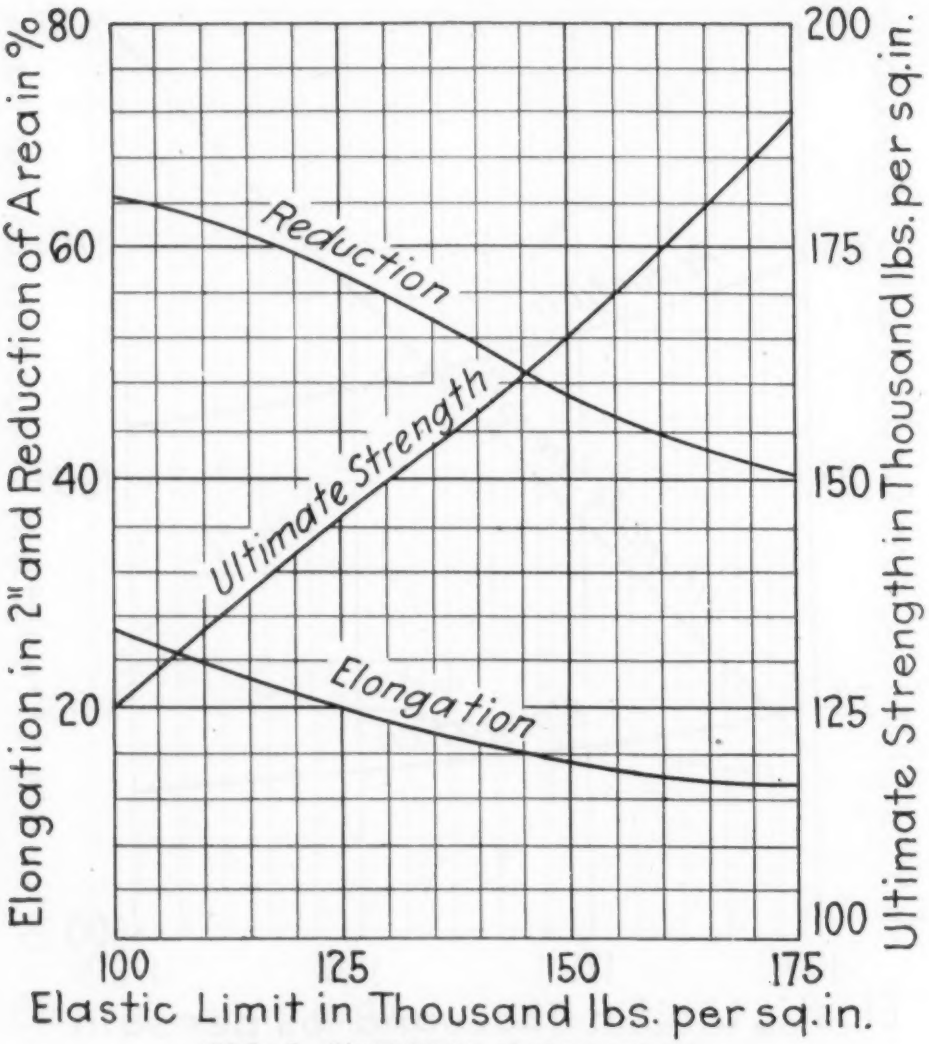


FIG. 4. CHROME VANADIUM

to the best of my knowledge the market quotations today, and that ought to be sufficient I think.

Member: As I say, I inquired as to what quotations you used, the maximum or the minimum, and the point is, which do you use?

Dr. Johnson: I would like to ask a question of Mr. Cutter. Is there any objection in sending in this paper for publication to incorporating the prices of the various elements on which these relative efficiencies of different steels are based?

Mr. Cutter: There is absolutely no objection to that, I think.

Chairman: Then you will have it so prepared for publication.

Member: I would say the paper or the charts are very misleading unless the prices of the alloys are given.

Dr. Johnson: The thought I have in asking this question, is that I understand Mr. Cutter in his prices based them on quotations he found in the leading journals. In that event his prices would certainly be high. I don't know of any quotation in the leading journal but what is higher than you can actually buy it for if you secured it in quantities, so if he has done anything he has rather been modest in his statement of the merits.

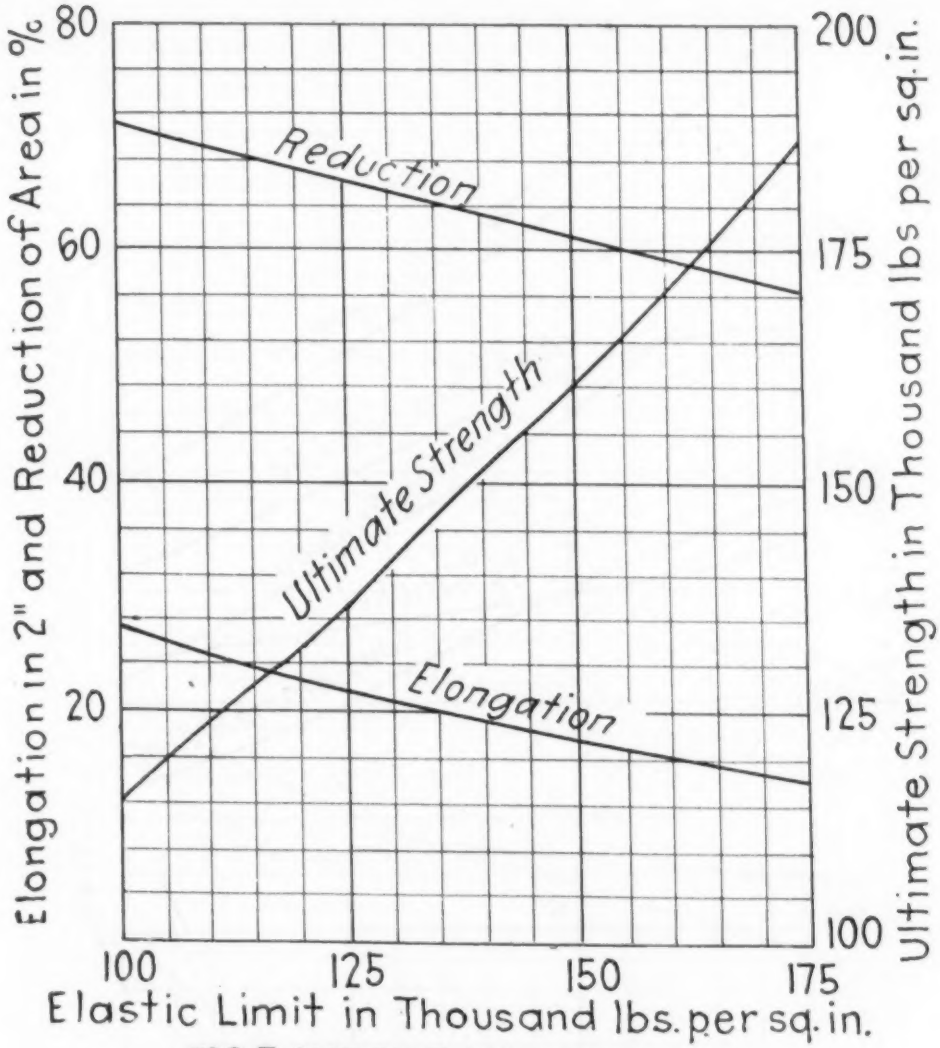


FIG. 5. CHROME MOLYBDENUM

Mr. Cutter: Thank you, Dr. Johnson. I think that the only process which I could follow was to take something which would be more or less standard. I might be able to buy vanadium or molybdenum at a very different price from some of my friends here, and the quotations applying to any individual would not be fair. I therefore took quotations that were as nearly standard as they can be made, as gotten from the leading journals, and it is understood perfectly from my paper I believe that these figures are not meant to be an absolute scale. The quotations were not secured for that purpose. And in any event it is interesting enough for you to investigate this method for yourselves and apply it to your own set of physical tests on the various steels and to your own quotations, and obtain your own results, and I am more than pleased that is the whole purpose of my paper, and if anyone thinks that some of these charts may be misleading, I will be very glad to individually go into them and show them the whole of my data from which the curves were plotted, and if it is thought by the committee that the actual market quotations which I used in developing these charts should be published with the paper, I will be very glad to have that done, or, if it should be decided that the charts

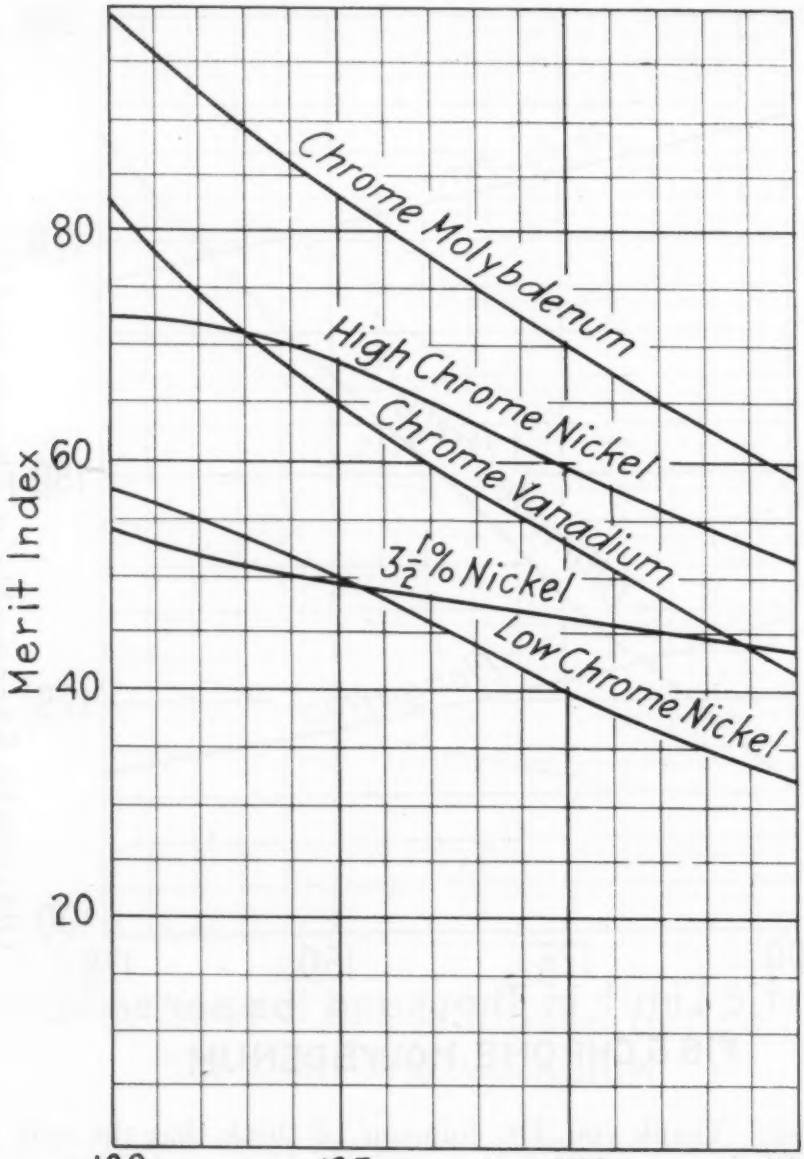


FIG. 6. MERIT INDEX

should not be published at all, it is absolutely immaterial to me. They are put in there for illustrative purposes, and my whole desire is to suggest this method of determining what I call the efficiency of the various combinations of alloys in steel, and if anyone will be interested enough to apply that method to their own data, the purpose that I had in writing the paper will be achieved.

Member: I would like to ask him if he has tried out at all any other merit index?

Mr. Cutter: Yes, I have experimented with a lot of them, but this one especially appeals to me, because it falls in line with the theory stated in the paper that the steel has merit in proportion to the ability of a unit

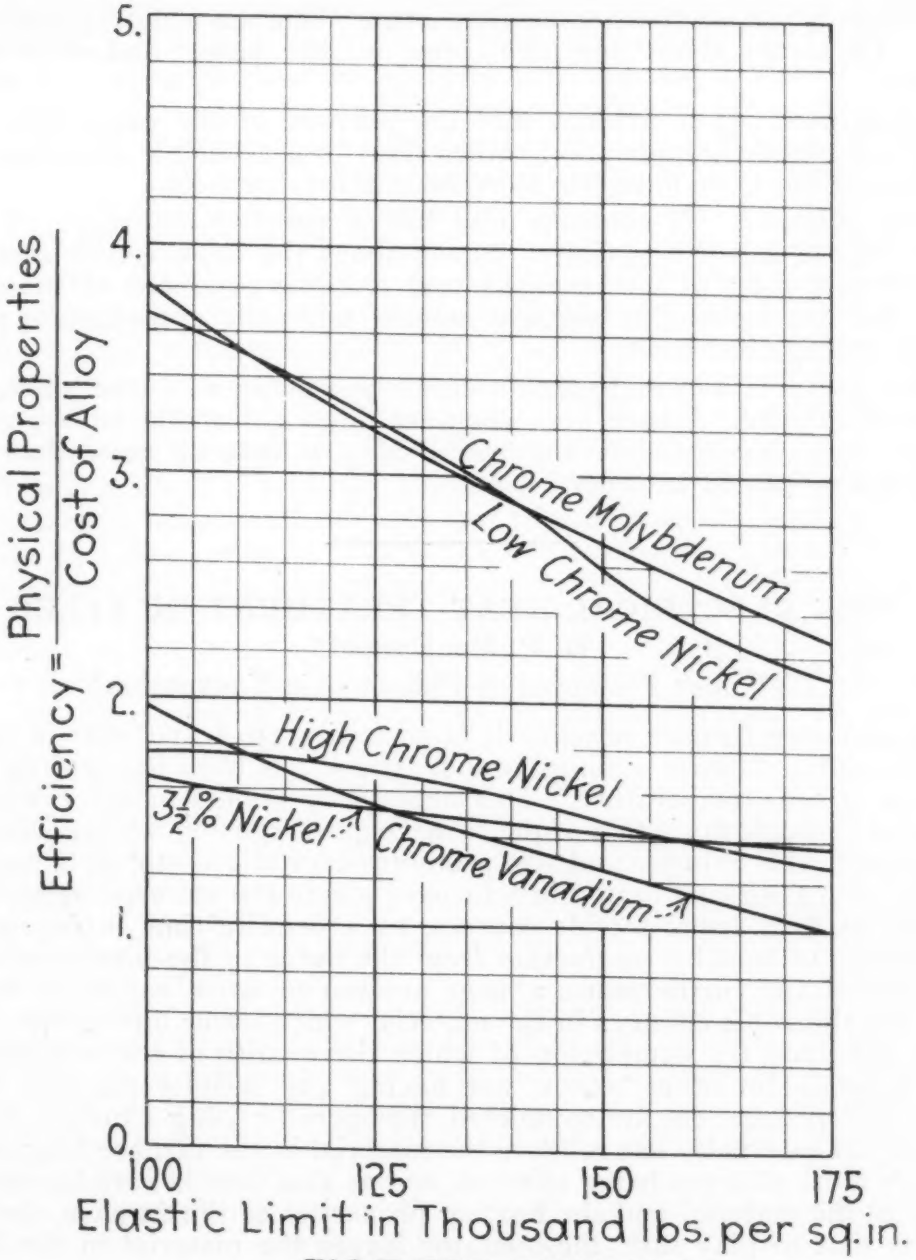


FIG. 7. EFFICIENCY

mass to withstand work done upon it, and if it hadn't been from that theory in the way it fits in with the merit index, I never would have written the paper.

Mr. D'Arcambal: May I ask Mr. Cutler, did you obtain these physical test results yourself or did you use different sources of data?

Mr. Cutter: There, again, I collected as many tests as I could, and I don't intend that the curves that I have shown shall be taken as a standard, either. The tests covered a wide range as to the size of section quenched and the source from which they came, and I tried my best to get something that would be an average result, from the S. A. E. and several other organizations, and averaged them up and I don't want to get into any discussion of them. My honest opinion is that they are very

representative of sections somewhat larger than the ordinary testing section. These are about one inch, some a little larger and some a little smaller.

Chairman: It is evident that the purpose of the paper was to describe a method of application rather than to establish a standard. Now our time is short, we have one more minute for discussion.

Dr. Johnson: If someone else has a question all right; if not, I would like to ask if Mr. Cutter knows about the approximate amount of molybdenum steel of this analysis that is being produced at the present time; that is, within the last few months what the approximate production in tonnage has been.

Mr. Cutter: I cannot speak accurately, Doctor, as to the tonnage that has been shipped. I have very accurate figures, I think, on the tonnage that has been ordered since the first of May, a little bit more than fifteen hundred tons placed on order.

THE ELECTRICAL HEAT TREATMENT OF STEEL

H. P. MacDonald*

(A Paper Presented at Philadelphia Convention)

In ordinary furnace practice it is customary to leave steel in the furnace through a definite soaking period, after it has been brought up to the required critical temperature. This necessarily results in deterioration of the metal through the action of the furnace gases causing scaling, decarbonization, and other injuries and also promotes crystal growth. It is necessary to have such a soaking period in a furnace where the material being heated receives its heat from outside sources, as a definite time is required for the transfer of heat by conduction from the outer to the inner portions of the material and furthermore, a large amount of work has to be done to affect the allotropic changes in the material which occur during the critical period and upon the completion of which the quality of the resultant material depends; in other words, not having any definite measure to tell when allotropic changes are completed, the operator using a furnace heating the material externally has to leave the material in the furnace long enough to insure these changes being effected, and as this time is variable with the section of the material and the heating properties of the furnace, the usual result is that to play safe, the operator leaves the material in the funace longer than is necessary.

In the heat treatment of steel by the electric method these difficulties are overcome. Referring to the accompanying cut of the apparatus used, it will be seen to consist of two sets of copper jaws (operated by pneumatic cylinders), connecting with which are the wires from the secondary of a transformer, designed to give heavy currents at low voltage. The upper contact remains stationary during the process, but can be adjusted to accommodate articles of varying length, the voltage being varied accordingly. The lower contact is free to move with the expansion or contraction of the specimen and to it is connected an indicating arm which travels over a dial to show the temperature of the specimen being heated. When the specimen is first put in the machine, the lower contacts are raised by means of a foot pedal shown in front of the cut, so that the indicator had

*Vice President, Snead & Company, Jersey City, N. J.

points to the room temperature. The piece is then placed inside the jaw and clamped.

This indicating mechanism is actuated by means of a pivot which is connected by worm and gearing to the drum on which the cable is wound which supports the upper contacts so that the application point of the pivot is varied with the length of the specimen and the indicator hand moves over equal intervals for the same temperature rises, regardless of the specimen length.

When the current is turned on by closing the switch, the material rapidly heats, due to its own internal resistance, and as it heats it expands until the critical point is reached. Here the expansion is either arrested or an actual contraction results, the material becoming noticeably colder and shortening in length. This contraction in the case of nickel steel often covers an interval corresponding to 150 degrees temperature.

While the current is on the operator watches this indicator and when this contraction ceases and the indicator begins to advance again showing an increase in temperature, the switch controlling the electric circuit is opened as are also the pneumatic operating jaws and the specimen is allowed to fall directly into the quenching bath below. It will be seen in this way not only is the critical point automatically shown up during the heat treatment, but also the operator is advised as to when the critical period has been passed and the article is in condition to be quenched.

The same apparatus is used for drawback, the article being then removed from the jaws and set aside to cool in the air.

The machine is at present being used for the heat treatment of nickel steel tubing for automobile propeller shafts manufactured by Snead & Company and in the case of tubing the quench can be affected by allowing the quenching compound to flow through the tube thereby quenching it in the machine and avoiding the necessity of a deep tank to contain the quenching bath in the case of long specimens. This apparatus is useful only with material having a constant cross-sectional area and through its use internal defects in the material can often be discovered. This feature is particularly valuable in the case of tubing, as thin spots in the center of the tube can be located by the increased temperature, spots which otherwise would never be discovered and might result in dangerously weakening the tube.

The accompanying charts show some of the phenomena observed during this process. These charts represent the average workings of ten specimens of steel having 3.45 nickel and .36 carbon. Chart #1 shows time and total B. T. U.'s and time and time and temperature, and on the latter, the reversal of the curves in the critical range can be readily seen. The dotted line represents the workings on a second heating after the first quenching operation and the critical point is at a noticeably lower temperature. It should also be noted how rapidly the temperature increases after the critical point has been passed showing how readily steel can be overheated.

The B. T. U. curve shows that while 142 heat units are required to raise the temperature to the critical point, 61 more must be added to complete the internal transformations necessary before quenching, in other words, thirty percent of the total heat units required are necessary to work allotropic changes which increase the latent heat without increasing the temperature of the article.

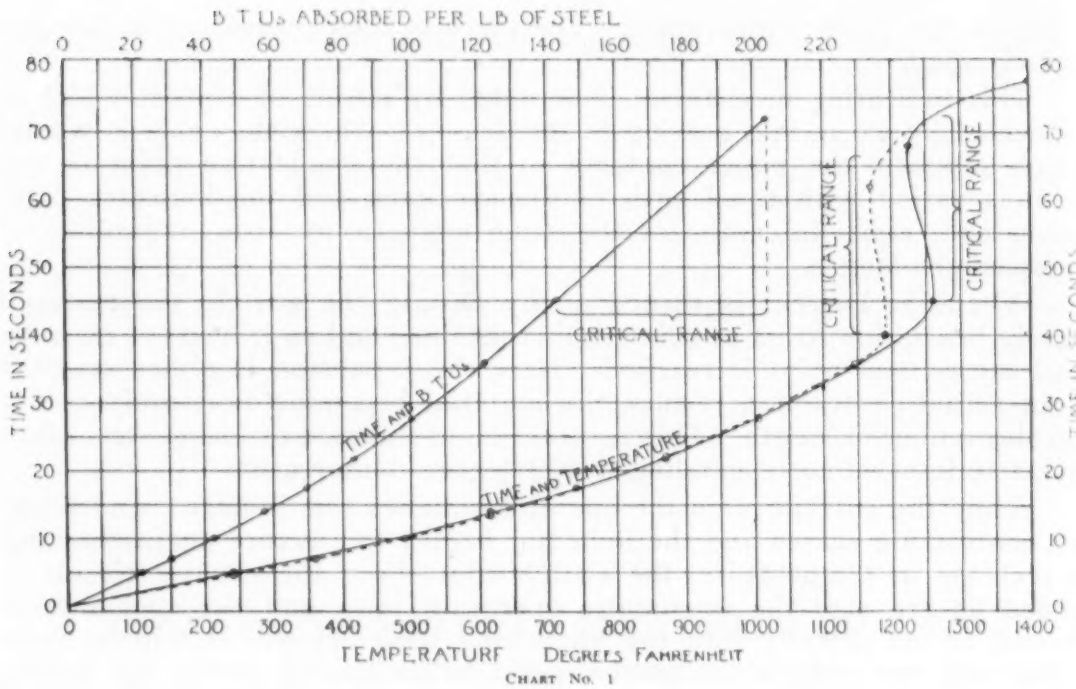

B T Us ABSORBED PER LB OF STEEL
0 20 40 60 80 100 120 140 160 180 200 220
TIME IN SECONDS
0 10 20 30 40 50 60 70 80
TIME AND B T Us
TIME AND TEMPERATURE
CRITICAL RANGE
CRITICAL RANGE
CRITICAL RANGE
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400
TEMPERATURE DEGREES FAHRENHEIT

CHART No. 1

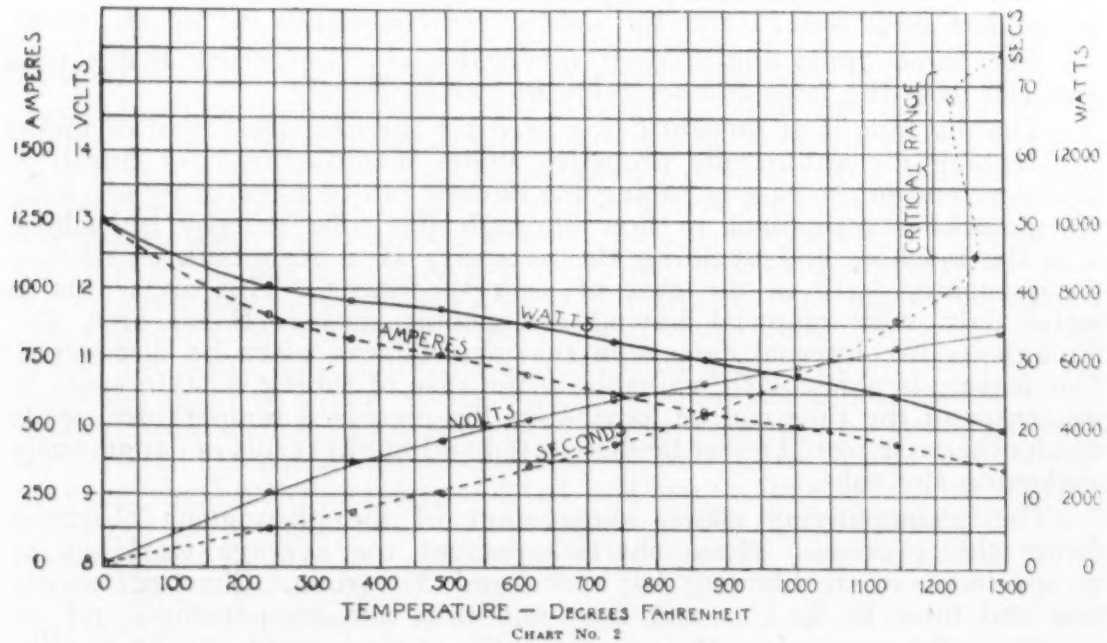
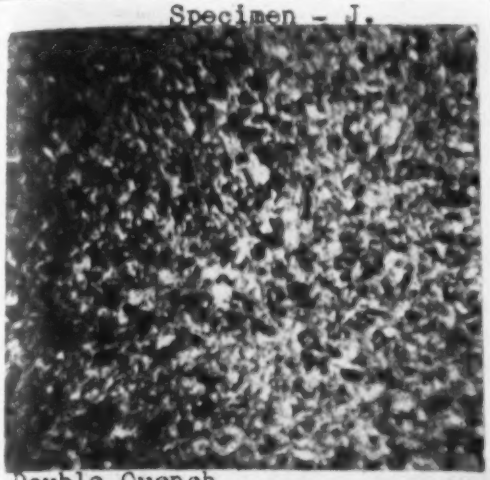


CHART No. 2

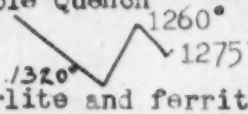
Chart #2 shows watts, volts and amperes, as well as time and temperature. Both these diagrams are based on runs where the heating was intentionally slowed down to enable the operation to be more readily observed, thirty to forty seconds in the average time required to heat a 16′ tube. Three volts to a foot length of material that is of the ordinary steels, are required and a current density of 8,000 ampers per square inch. Solid bar stock takes about .06 of a kilowatt hour per pound of material heated to its critical point.

A series of experiments were made to show if there were any higher qualities obtained. the steel of this character through a double quench and the accompanying micophotographs and table #1 show the results

Specimen - J.

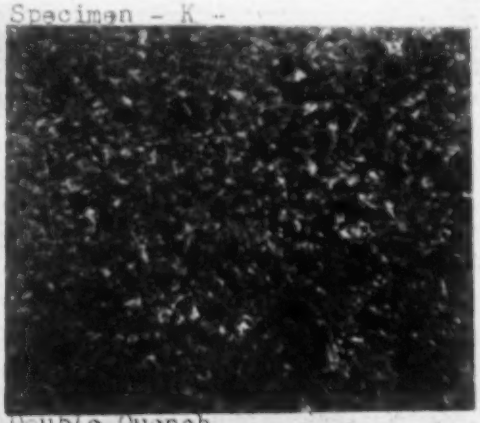


Double Quench

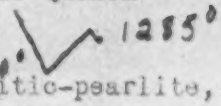


Pearlite and ferrite. Well distributed - evenly divided.
Ult.Str. - 229,250 lbs.sq.in.
Yield Pt.- 210,350 lbs.sq.in.
Elongation in 2" - 10.5%
Reduction in area - 53.5%
Fracture - semi-cup, silky.
Magnification - 500 dia.

Specimen - K -

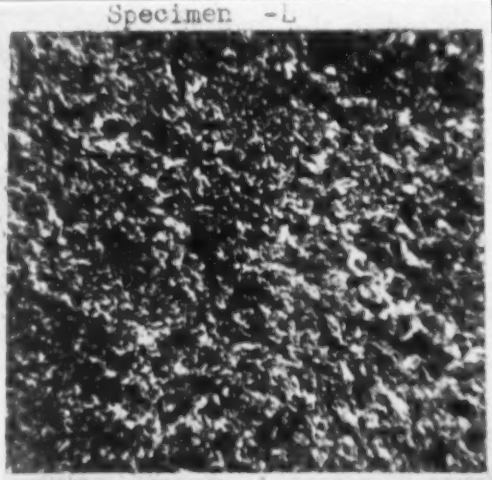


Double Quench

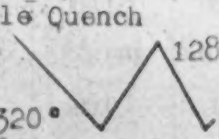


Sorbitic-pearlite, well distributed, evenly divided
Ten. Str. - 238,800 lbs.sq.in
Yield Pt. - 206,200 " " "
Elongation in 2" - 9.75%
Reduction of area - 53.0%
Fracture - full cup, silky
Magnification - 500 dia.

Specimen - L

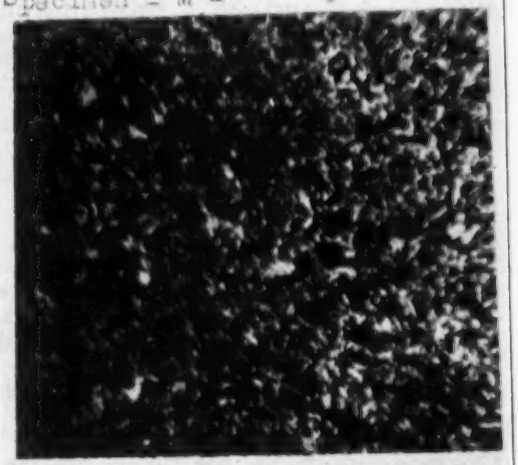


Double Quench

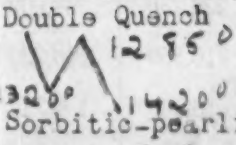


Pearlite and ferrite. Shows tendency to segregation.
Ult. Str. - 238,900 lbs.sq.in.
Yield Pt. - 200,125 lbs.sq.in
Elongation in 2" - 11.5%
Reduction of area - 52.1%
Fracture - semi-cup, silky
Magnification - 500 dia.

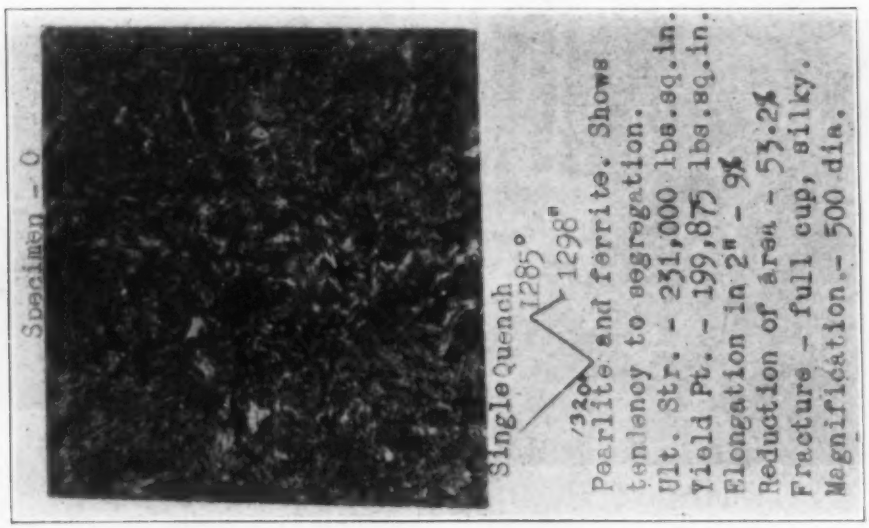
Specimen - M -



Double Quench



Sorbitic-pearlite, small amount of slag
Ten. Str. - 231,900 lbs.sq.in
Yield Pt. - 203,050 lbs.sq.in
Elongation in 2" - 9%
Reduction of area - 53.65%
Fracture - full cup, silky
Magnification - 500 dia.



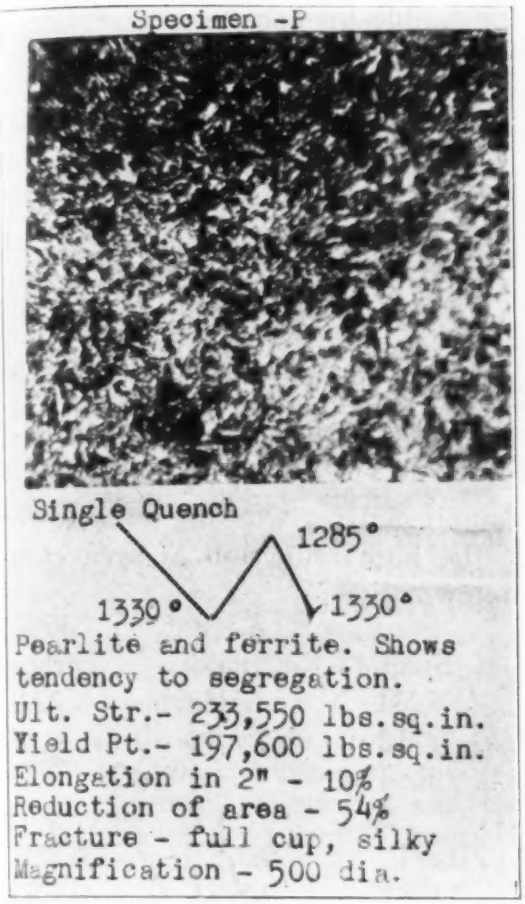
of this and the structures obtained.

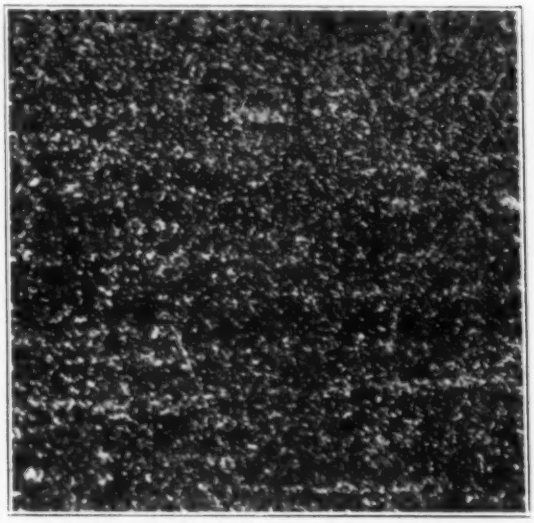
The zig-zag lines below each microphoto show the time at which the specimen was quenched, i.e., the left hand line represents the advance in heating the material, the center line the contraction during the critical period, and the right hand line, the expansion occuring before quenching. It will be seen that excellent results are obtained by quenching as soon as this expansion begins, and also a tendency to segregation if the temperature is materially increased. This material was cold rolled bar stock 3.48% Nickel and .38% Carbon and was tested in the original sizes.

PROPERTIES OF 3½ PER CENT NICKEL STEEL

Specimen*	J	K	L	M	O	P
Nickel, per cent....	3.46	3.47	3.48	3.46	3.48	3.48
Carbon, per cent...	0.39	0.39	0.39	0.39	0.39	0.38
Structure	Sorbitic-pearlite Well distributed evenly divided	Sorbitic-pearlite Well distributed evenly divided	Sorbitic-pearlite	Sorbitic-pearlite	Sorbitic-pearlite	Sorbitic-pearlite
Amount of slag....	Small	Small	Small	Small	Small	Small
Ultimate strength, lb. per sq. in.....	229,250	238,800	238,900	231,900	231,000	233,550
Yield point, lb. per sq. in.....	210,350	206,200	200,125	203,050	199,875	197,600
Elongation in 2 in., per cent.....	10.50	9.75	11.50	9.00	9.00	10.00
Reduction of area, per cent.....	53.50	53.00	52.10	53.65	53.20	54.00
Fracture	Semi-cup, silky	Full cup, silky	Semi-cup, silky	Full cup, silky	Full cup, silky	Full silky
Treatment	Double	Double	Double	Double	Single	Single
Drawing temperature, deg. fahr.....	630	630	630	630	630	630

*Letters refer to photomicrographs.





Steel Tube from Drive Shaft
Magnification, 100 dia.
Single Quench and drawn back at 800° F.

Table #2 gives another set of tests which clearly show the necessity for allowing sufficient time for the complete allotropic changes to take place and that when once this has been accomplished, no further gain can be made by prolonging the heat.

Specimen	Elongation in 2 in., per cent	Reduction in Area, per cent	Yield Point, lb. per sq. in.	Ultimate Strength, lb. per sq. in.	Period of Quenching
3C	9.75	41.90	126,550	181,550	After being in critical period 12 sec.
3H	9.00	50.90	154,150	175,500	After being in critical period 15 sec.
3K	11.75	43.45	140,400	175,400	After being in critical period 10 sec.
3L	9.50	52.20	202.400	227,300	After being in critical period 29 sec.
3D	10.00	52.60	201,350	223,350	Just through critical period.
3E	10.00	56.70	198,800	216,150	120 deg. fahr. above the critical period.
3F	11.50	58.30	193,300	212,250	240 deg. fahr. above the critical period.

Table #3 gives the same results for double quench.

Specimen	Elongation in 2 in., per cent	Reduction in Area, per cent	Yield Point, lb. per sq. in.	Ultimate Strength, lb. per sq. in.	Period of Quenching
3A	19.75	56.25	83,050	117,650	After being in critical period 15 sec.
3G	11.50	56.90	202.300	216,150	Just through the critical period.
3J	10.10	53.85	203,600	214,250	95 deg. fahr. below the critical period.

Table #4 shows what can be accomplished by working to a lower drawback temperature and in this case the high reduction of area combined with the ultimate strength are noteworthy.

		3.5%	.36%
Material	Steel	Nickel	carbon
Laboratory Test Number	7234	7235	7237
Mark on Test Piece	12	12	13
Shape of Test Piece	Rod		
Guaged length, in inches	2	2	2
Diameter, in inches	0.371	0.371	0.371
Area in square inches	0.1081	0.1081	0.1081
Diameter at fracture	0.289	0.289	0.283
Area in square inches	0.0656	0.0656	0.0629
Elongation in 2 inches	0.23	0.21	0.20
Percent Elongation	11.5	10.5	10.0
Percent Reduction of area	39.4	39.4	41.8
Yield point, in pounds	20000	20500	20500
Maximum load, in pounds	28920	28830	28840
Yield pound, lbs. per square inch	184900	184900	189600
Ultimate Strength, lbs. per sq. inch	267300	266500	266500

A number of tests have been made by the Company and others on their own product. Noteworthy among these are tests made by the H. H. Franklin Company. This is on a shaft using tubing of 3½% nickel steel, .25-.35 carbon, 1¼" diameter—16 gauge, given a single quench and drawn back at 700 degrees. These shafts were 45" long.

No. 1

Torsional moment at elastic limit	14200	inch pounds.
Shearing stress at elastic limit	109000	pounds per square inch.
Torsional moment at max. strength	15700	inch pounds
Shearing stress at max. strength	120500	pounds per square inch.
Angle of torsion at elastic limit	48	degrees
Angle of torsion at max. strength	112	degrees

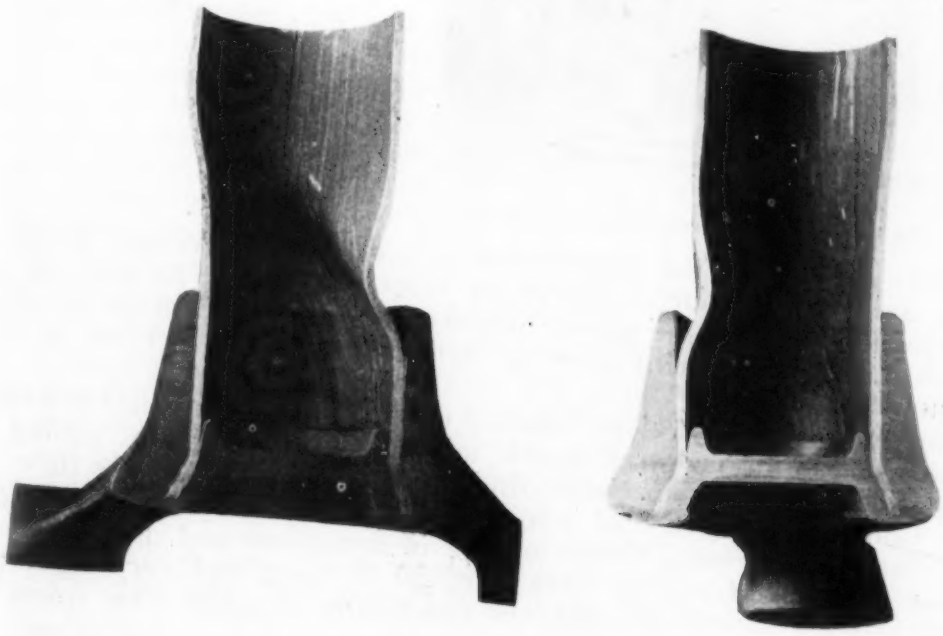
No. 2

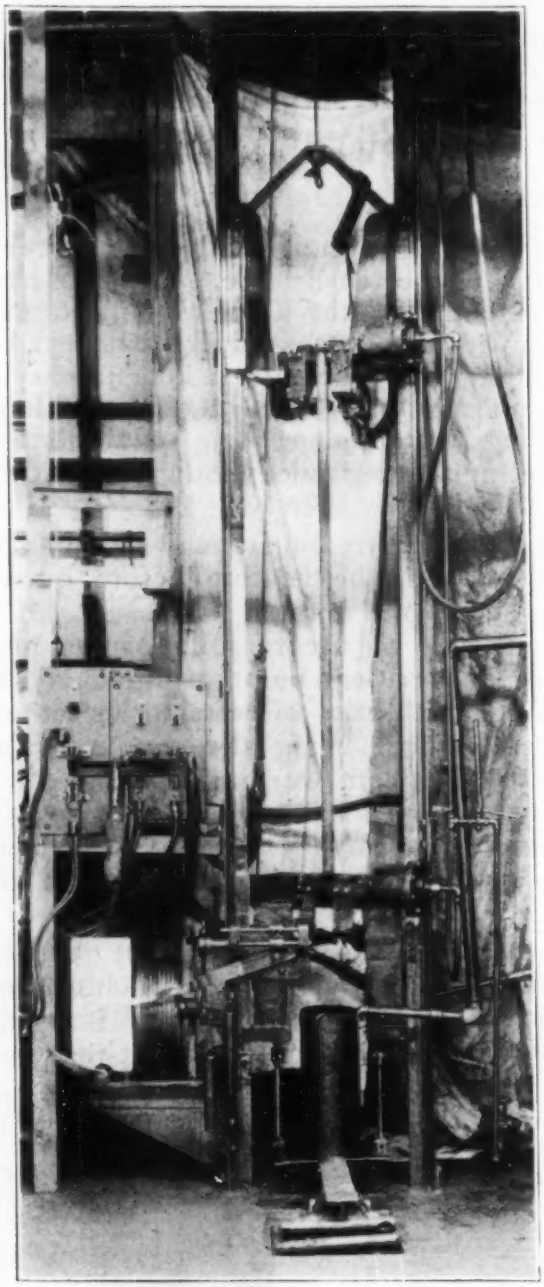
Torsional moment at elastic limit	14700 inch pounds
Shearing stress at elastic limit	113000 pounds per square inch.
Torsional moment at max. strength	15750 inch pounds
Shearing stress at max. strength	121000 pounds per square inch.
Angle of torsion at elastic limit	50 degrees
Angle of torsion at max. strength	120 degrees

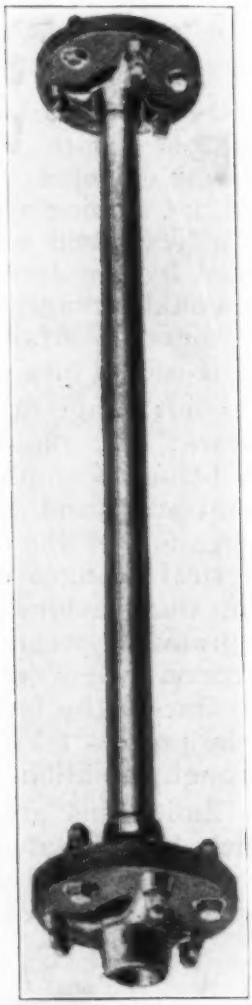
Tests have shown that for this light gauge tubing, the torsional strength per square inch is about .6 of the tensile strength. These results are typical of what has been obtained by the Company in its regular product, i.e., tubing with the dropped forge steel spiders attached by the use of a hexagonal wedge expanding the tube into a hole in the spider as shown by the accompanying photograph. This method develops the full torsional strength of the tubing without depending on welds to take up the torsional strains. The accompanying micophotograph shows the section of such a tube enlarged 100 diameters. See page 203.

The advantage of this method of heat treatment may be summarized as follows: The rapidity of the process, the heating before quenching usually being accomplished in less than one minute, the absence of scale, decarbonization and crystal growth due to the rapidity of the process, the indication of the temperature and critical point of the material by the physical changes in material itself, absence of refractories, (the only parts of the machine needing replacement being the copper contracts, which gradually wear out) the freedom from warping and the low cost of operation when current can be obtained at reasonable prices. This latter is due to the fact that virtually the entire energy is used in useful work, the process taking place so rapidly that comparatively little heat is lost through radiation.

Its limitations are those of requirements of a constant section for the article being heated (this section need only have a constant area, the shape may vary) and the fact that when alternating current is used, the element of reactance of the circuit comes in to such an extent that greater







Machine used for Electrical Heat Treatment

voltage is required at the transformer to overcome it. Where direct current is available no such element of reactance comes in and the only requirement would be the proper initial voltage and amperage of current available. The equipment now in use is limited to sections of about 1¼ square inches.

The process was developed during the late war in connection with the execution of an order for Cossack lances made from steel tubing, the specifications requiring an elastic limit of about 83,000 lbs. As time went on the Company made use of it for the heat treatment of steel tubing for the Italian Royal Flying Corp. for use in aeroplane and dirigibles, some of these sections of tubing were over 20 ft. long and very light gage. nevertheless they were brought out practically straight after quenching.

Later on when this country got into the war we heat treated tubing used for the landing chasses of the Handley Page aeroplanes made at Elizabeth, New Jersey, and were working with the Dayton Wright Company in connection with heat treating their airplane axles at the time of the armistice. On sample shafts furnished by us composed of 3½% nickel steel, their tests showed an elastic limit of 220,500 lbs. and an ultimate strength of 246,000 lbs. with 6½% elongation in 2", more than satisfying the government specifications. It is important to note in this connection that tubing and shafting can be heat treated to high tensile strength without serious warping, this appears to be due to the fact that the material is heated simultaneously throughout its section rather than having the heat soak in from the outside.

It is also interesting to note that the critical periods appear to occur at a lower temperature than in ordinary furnace work and that the physical results are much higher than those ordinarily obtained by the same material. The former is possibly due to some electrolytic action in the steel, due to the passage of current and the latter to the complete control incidental to the process and possibly to the more thorough allotropic transformations.

DISCUSSION OF MR. MACDONALD'S PAPER

Chairman: To me this is something of an innovation in the method of steel treating. Perhaps it is not so to some of you, but I imagine it is a very interesting subject and will bring forth some discussion. The floor is yours now to fire all the questions you dare to at Mr. Macdonald.

Mr. Rockwell: I will ask you if you found any difference in your warpage or expansion by dropping down just before the recalescence before quenching? That is, your pointer shows expansion and then contraction and then at the starting to turn for expansion again you shut the heat off. Supposing you follow down until just the point before you start to expand again. If you should quench in there would you find any difference in the structure, in the physical properties and the warpage?

Mr. McDonald: We found a very material difference there. If you don't get over that kink, if the points begin to show an increase in temperature again, the physical values fall off very materially.

Mr. Rockwell: I mean after your pointer has gone over, started to expand on the heating,—you heat up, you expand, as you go through your critical range you contract, then you start to expand again,—your change has been made, then you cut the temperature off; supposing you let it fall down just before the point she starts to expand again?

Mr. MacDonald: That would go down too low, I believe to get it.

Mr. Rockwell: You are still above the critical range.

Mr. MacDonald: I have not tried that.

Mr. Rockwell: I have tried it out in a small way on small tools by heating in an electric furnace and supporting my work on silica plates and I noticed that function as read directly off on an Ames Dial, and I got some remarkable results that way. I cut the warpage way down and stopped the scaling and stopped grain growth. My attempts were very successful.

Mr. Marshall: May I ask if you applied that method at all to any higher carbon steels what would be the effect?

Mr. MacDonald: We haven't tried it out on any higher carbon steels.

Mr. Marshall: The tool steels we always handle with care, and the rapid heating would seem a drastic treatment.

Mr. MacDonald: It seems drastic, but when you come to look at it you are heating the material simultaneously through all the section. If you put the material in a furnace that is very hot the outside of the material is heated first. Therefore you get very heavy internal stresses, but if you raise the temperature uniformly throughout the mass, simultaneously, you don't get that condition. I think you would get pretty much the same thing in 3.5 per cent nickel steel that you would with the other. Well, I recently heat treated a rear axle spindle for a full floating axle for an auto truck. That was quite a high carbon steel, I think about .50 carbon, and we had no difficulty there at all. That had splined ends but the spline was so designed that it had practically the same area as the rest of the section, and we had no difficulty.

Mr. Hurley: I would like to ask Mr. Macdonald how you keep the ends of a propeller shaft as hard as the central section. I should think the clamps would draw away a certain amount of heat.

Mr. Macdonald: We don't. The ends about an inch and one-half on each end, are not heated, and we cut them to waste. That is one reason why we use the heat treatment in long lengths. We cut them in 16 feet lengths and cut them to average up only 14.

Mr. Decker: Is there any reason why you couldn't make that to handle stock an inch and a quarter?

Mr. MacDonald: There is no reason except the electric current available. We are drawing on the city power there and we are taking about all we can have. It is a pretty heavy kink on the load you know to throw that right across the line, and we can only use single phase: that means we are only drawing off one side of a two phase circuit. A direct current is the ideal way to handle a thing of course.

Mr. Rockwell: Could you use that in a continuous process for heat treatment of wire?

Mr. MacDonald: I don't see why not. Of course it is different with the continuous process; you wouldn't be able to get the measurements like we do now. It has been used. The same method has been used for annealing wire where you simply heat it up to a definite temperature and of course where you don't have to work quite so closely I don't imagine you would need (interrupted).

Mr. Rockwell: You could first establish your temperature by your voltage, by your dial, and hold it there.

Mr. Ryan: Has that process been used very extensively for the heating of rivets?

Mr. MacDonald: There is an electric process used quite extensively for rivet heating, but that is a different proposition. What we have here is no temperature measurement other than by eye, and it is largely a matter of contact resistances as well as internal resistance in heating there.

Mr. Hurley: Mr. MacDonald said that on the quenching heat it took about forty seconds to effect the necessary changes before you quenched it. Does it take longer than that on the draw?

Mr. MacDonald: O, no, the draw takes very much less time, probably only twelve seconds. You see you have a good part of the time in the critical period when you are quenching. Those moving pictures give you a very good idea of the time it takes. I think they are run off a little bit more rapidly than the actual process.

HEAT TREATMENT OF TRUCK AXLES

Harry E. Hemstreet*

(A Paper Presented at Philadelphia Convention)

Heavy worm drive Motor Truck Axles are unit parts of various kinds of steel assembled together as a load carrying member of the truck, and as such must be capable to deflect without deformation. The Designing Engineers speaking of them claims actual stresses on parts in service is unknown, or the finest scientific calculations, mathematically figured from beam stresses of material, are virtually hopeless in determining factors of safety accurate for unit parts, only the acid test of actual road performance being reliable where distructive forces are constantly at work on the material of construction when in service. These unit parts are subject to all known stresses of material, and as a factor of safety in longevity of life for serviceableness must receive careful applied steel heat treatment.

All material before entering into Axle manufacture has the chemical analysis taken, sample pieces of each individual heat of steel is heat treated for laboratory test purposes, where pieces are examined under the miscroscope for impurities and the nature of its physical structure, others pulled apart, torsion and transverse tested.

The Metallurgist in axle manufacture has cast steel annealed, drop forged parts case hardened and triple heat treated, parts machined from screw stock, case hardened, triple heat treated, drop forge, yokes, knuckles, side axles, break levers, steering levers, connection rods and connecting rod clevis, which are all normalized, hardened by quenching and tempered. All axle parts receive a 100 per cent hardness test, either by Brinell hardness test or Scleroscope method, which necessitates having a good heat treating equipment and heat treating all parts by a heat treating card which specifies heat temperatures according to the chemical analysis of the heat number of the steel used in manufacture of the parts.

Only such parts which are hardened by quenching will be taken up in this article, other heat treating methods used being covered by other papers.

The steel on arriving in the forge department is heated to be forged into the various shapes, such heating is of great importance on the physical structure, qualities of the part after final heat treatment, also regulates the time and temperature for final heat treatment. Too great a care can not be exercised in this department in heating, for if the structure of the steel has a fine grain structure at the end of the last forging operation, steel not overheated previous, then the hardening and tempering operation on the final treatment is sufficient for a good commercial product.

It seldom pays to eliminate the normalizing and seldom is done for the parts by the use of this method are all made uniform in physical structure first, such uniformity will be the test results on all parts, after hardening and tempering with accurate temperatures in heating.

The heating temperature generally used in forging is between 2,000° F. and 2,100° F. to make the steel plastic in hammering it, while such work generally stops at around 1,500° F. and is allowed to air cool. Temperature control of the forge furnaces with plenty of furnace floor space for heating, so that the specified working temperature has time to heat the metal plastic clean to the core, is the ideal conditions of forging steel. The forgings where heated at the lowest possible temperature will have a

*Sheldon Spring & Axle Co., Wilkes-Barre, Pa.

smooth and cleaner looking surface, less change of ferrite segregation spots, and be more uniform for length. The old system some used with the lack of furnace capacity was forcing the heat applied to make adequate production, which caused the steel to become nearly liquid or even so that it dripped when being moved to the hammer. Such high temperature generally causes a heavy scale which is not easily removed from the die, thereby becoming hammered in the steel; these forgings, alas, have a very coarse grain structure which requires more time at a little higher temperature in normalizing than ordinary. Overheated forgings look anything but mechanical for mechanical workmanship. Some parts require from three to five heats in forging and each heat should be carefully controlled so that the finished product will show neatness of workmanship, showing up the lines of gracefulness in design of the part. It is only human nature for men working piece work if their furnace heating capacity is not great enough for continual working heat to increase the temperature a little more than necessary for forging the steel part, which in most cases where allowed or done there occurs trouble in the machining of the steel even after heat treatment for the coarse crystalline structure so caused needs special attention, other than the regular methods to thoroughly refine the crystalline structure of the steel to non-crystalline when once overheated. The best method at all times is making sure of not having any more grain growth than is absolutely necessary for drop forged parts, the same will lessen the burden in final heat treatment and machining. There is no question of a doubt but the best remedy for controlling drop forge heats is the applying of good common sense from test results, and other mechanical operation where overheating has caused trouble before. The front axle yoke which is hammered into an I-beam type of construction, forging a pad near the ends to fasten the spring to, and shaping the clevis ends for inserting the steering knuckle receives six different heats at least in forging the last heat taken being a normalizing heat when the drop, if specified, is put in the bed of the axle and alignment in straightening is done.

The yokes are generally forged from a straight 30 to 40 per cent carbon steel with heat treatment adjusted to a tensile strength of 85,000 to 95,000 lbs. per square inch, elastic limit of 50,000 lbs. per square inch, elongation, 22 per cent, 2 inch, reduction of area 45 per cent, which gives good ductility for machining. The yokes in heating to harden are loaded in an under-fired combustion chamber furnace in a layer with the top side of the axle up, which gives the spring pads ample heating contact with the heat, as this is the thicket part of the yoke to heat. The amount of weight and diameter of the thickest part regulates the time of heating, which, as a rule, comes close to one hour, 20 minutes, for 600 lbs. at an approximate thickness of 1¼" at thickest part, temperature 1,550° F. On being quenched in water, they are lowered in very quickly, being agitated till the steel drops below the critical range then left at rest; separate till about 200° F., when the part is removed and loaded on trucks for tempering. The parts are held at the tempering temperature one hour after maximum heat has been reached then allowed to air cool, Brinell hardness being 217 to 228.

The rear side axles, steering-knuckles, steering and break levers require steel, having a higher elastic limit, so the side axle is made of a 3½% nickel steel, 30 to 40 per cent carbon; other parts 1½% nickel steel. Side axles require a careful heating for physical properties, sufficient to carry load while revolving and withstand the impact road shocks, torsion

and transverse stresses. The drive shafts are first normalized, air cooled till cold, then reheated from 1,450° to 1,475° F. being given ample time to heat, then the heavy part at the hub shoulder, which is about 1/3 more in diameter than the differential end of the axle shaft without causing grain growth on the smaller end while the larger is heating. These side axles are water quenched in a temperature regulated bath, agitated while cooling below the range then being removed while about 200° F., immediately loaded in the oven for tempering, being held at the maximum tempering temperature 1½ hours in time. Steering knuckles, brake levers and steering levers are quenched in oil at 1,500° F. tempered for the same Brinell hardness as the front yokes.

One of the main factors in heat treating steel is keeping the parts in alignment so that they do not have to be straightened or twisted in order to true them up before machining. Skill in quenching alone regulates the amount of such work, providing the heating has been done uniform. The quenching horizontal of parts must be done quickly, raising the part upward again right after emersing in the quenching medium and lowering till the part is cooled below the critical range.

Where parts do have to be straightened or twisted the steel should first be heated to at least 400° F., then it will still be classed as cold working of steel; the effects though, will not be so severe as actual bending cold. Better to straighten any part which may be out of alignment when the material is removed from the tempering furnace, as then the parts are thoroughly heated through. Such work upon the material while heated shows no defects under microscopic examination.

Factories having a large enough capacity for the installing of a conveying type furnace, are finding the parts heat treated by their use, of excellent quality with very little variation in hardness test and physical test. These conveying type furnaces seem to be the ideal way to heat treat axle parts, as the heating temperature rise is gradually applied till the maximum temperature desired is attained, when the parts are allotted a certain time at full temperature, then progressively passed out of the furnace into the quenching bath, conveyed through the quenching medium upon a tempering conveying furnace which also regulates the time of tempering temperature for an absolute positive heating through to the center, which gives a ductile steel for machining operation of uniform strength.

Mechanical contrivances in heat treatment are becoming universally used now, which corrects a great many evils of defective heat treatment by regulating necessary time, mass and temperature.

NOTICE

CHANGE OF HEADQUARTERS

Beginning November 20th, 1920,
address all correspondence to

AMERICAN SOCIETY FOR STEEL TREATING

4600 Prospect Avenue
CLEVELAND, OHIO

CHAPTER NOTES

CHICAGO CHAPTER

The Chicago Chapter held the November meeting in the rooms of the Western Society of Engineers at 7:30, Wednesday evening, November 17th. Mr. Robert B. Kerr, foreman, heat treating department, John Deere Harvester Company, East Moline, Ill., presented a paper on the "Hardening of Hammer Die Blocks."

Mr. Kerr has had years of experience in this work, and presented in a very interesting and instructive manner the methods he had employed with such satisfactory results. The subject was of great interest to the membership present, and brought forth some of the most interesting discussions that the Chicago Chapter has ever experienced.

The next meeting of the chapter will be on December 14th, when Mr. Howard Stagg, assistant manager, Halcomb Steel Company, Syracuse, N. Y., and a member of the board of directors of the National Society, will be present at a dinner meeting and present a paper.

In the same letter, containing the announcement of Mr. Kerr's meeting, was enclosed an announcement relative to the establishment of educational courses by the Educational Committee of the Chicago Chapter, of which Mr. T. E. Barker is chairman. The announcement follows:

Announcement

The Armour Institute and the Lewis Institute, with the co-operation of the American Society for Steel Treating, will soon open evening courses on forging and heat treatment of steel.

These courses have been especially planned by our Educational Committee for the benefit of the practical workers, and those who wish to qualify for such work.

The courses will embrace the following phases of the work:

"The Pyrometer."

"The Microscope."

"Forging (showing effects of proper and improper heats and conditions)."

"Annealing."

"Alloy Steels (dealing with the effects of different alloys and treatments upon the physical characteristics of steel)."

"Hardening and Drawing of Tool Steel."

"Case Hardening."

Seven sub-committees, each composed of three of our members who are actively engaged in the metal working industries of our community, have each prepared one of the seven texts covering the seven phases above mentioned and will teach their subject by practical methods to these classes.

The members of the above mentioned committees have been actuated in this work purely by a desire to be of service. None will receive financial compensation for preparing these texts, lectures, and demonstrations. Will you not, therefore, do your "bit" in the interests of our society and the schools, by giving this announcement as much publicity as is possible among those of our associates, either in or out of your plants, who you think might profit from the course?

Those interested should, for further particulars, address: Armour

Institute of Technology, Thirty-third and Armour avenue, or Lewis Insitute, Madison and Robey streets.

CLEVELAND CHAPTER

About 150 members of the society were present at the October meeting of the Cleveland Chapter held at the Cleveland Engineering Rooms, Statler Hotel. The Program Committee was very fortunate in obtaining as a speaker one of the very busy fellow members and one who has had wide experience in the manufacture of steel, Mr. Howard J. Stagg, assistant manager, Halcomb Steel Company, Syracuse, N. Y., who delivered a very capable paper. The discussion following the paper was very interesting and brought forth many valuable suggestions for solving various difficulties.

BUFFALO CHAPTER

Mr. Jos. V. Emmons, metallurgist, Cleveland Twist Drill Company and chairman of the Cleveland Chapter, presented a paper before the Buffalo Chapter on Monday evening, November 1st, on "The Heat Treatment of High Speed Steel." The meeting was held in the assembly room of the University Club and proved especially valuable to those who were in attendance.

INDIANAPOLIS CHAPTER

The October meeting of the Indnanapolis Chapter was addressed by Prof. Moore of the University of Illinois, who selected as his subject the "Fatigue of Metals." Prof. Moore's paper was illustrated by lantern slides, and was the result of extensive research work that he has conducted in the laboratories of the University of Illinois.

The meeting on November 5th was addressed by Mr. Charles M. Johnson, director of research department, Crucible Steel Company of America, Pittsburgh, Pa. Mr. Johnson told of his work in the development of a new steel and also assured the members that his article would be ready for publication in the transactions as soon as he had finished the preparation of some additional work.

The annual visit and inspection of the Indianapolis Chapter took place on Friday evening, November 19th, when President White and the National Secretary Eisenman were present. They were met by the Convention Committee of the Indianapolis Chapter and spent the day investigating Indianapolis as a possible location for the 1921 Convention and Exhibition.

DETROIT CHAPTER

About 150 were present at the October 27th meeting of the Detroit Chapter, when Dr. George W. Sargent of New York presented a paper on "Molybdenum Steels." Dr. Sargent showed the results of a number of tests that had been made with the use of molybdenum as the alloying element and also presented some interesting facts as to the method of mining molybdenum. President White and the National Secretary Eisenman were also present at the meeting and addressed the membership.

CINCINNATI CHAPTER

The November meeting of the Cincinnati Chapter was held at the Ohio Mechanics Institute on Friday, November 5th. The feature of the meeting was a report of the Philadelphia Convention by Dr. Hartzell of the Victor Safe & Lock Company, Mr. A. L. Meyers and Mr. Harold LeBlond of the R. K. LeBlond Machine Tool Company. The outline for the coming year was presented and discussed, as was also the advisability of holding the 1921 Convention and Exhibition in Cincinnati.

The second November meeting of the Cincinnati Chapter was addressed by President White and National Secretary W. H. Eisenman, at the Business Men's Club on Thursday evening, November 18th. These gentlemen spent the day in Cincinnati with the Convention Committee and the Secretary of the Chamber of Commerce, and investigated the city as to the advisability of its being able to accommodate the 1921 Convention.

MILWAUKEE CHAPTER

The November meeting of the Milwaukee Chapter was held at Hotel Medford at 8 p. m. on Monday, November 29th. A very interesting and illustrated paper was presented by Mr. A. F. MacFarland, of the Vanadium Alloys Steel Company, on the subject, "Some Notes on the Heat Treatment and Structure Characteristics of High Speed Steel."

TRI-CITY CHAPTER

The Tri-City Chapter celebrated the founding of their chapter at a dinner meeting and smoker on Friday evening, November 5th. In order to properly portray the spirit they are showing, in getting out an attendance, the notice is printed below.

First Annual Meeting American Society for Steel Treatment, Friday Evening, November 5th, 1920

Dinner-Smoker Meeting, Davenport Commercial Club. Dinner, 7-8 p. m. $1.50 per plate. Meeting 8 p. m., sharp.

Speaker: Capt. H. B. Knowlton.
Subject: Case Hardening.

Capt. Knowlton comes to us from the Case Hardening Service Company of Cleveland, as their metallurgical engineer. He is a national authority on case hardening and this is an opportunity that no member can afford to miss.

As this is our first annual meeting, and we are in the midst of a membership drive, we expect every member to attend and bring as many prospective members as possible.

Call Moline 791 and make reservations for yourself and friends. Get your reservations in by Wednesday, the 3rd, if possible.

If it is inconvenient for any members to get to the meeting in time for dinner, please call Mr. Gust Olson, Jr., at Moline 612, and he will arrange for members to come by automobile.

All members driving cars are expected to get in touch with Mr. Olson and donate their services for this purpose.

Let's get behind this, our first annual meeting, and make it a success!

HAROLD BROWN,
Secretary-Treasurer.

The meeting was a decided success. Over 100 attended the dinner.

SPRINGFIELD CHAPTER

A very interesting meeting of the Springfield Chapter was held on November 29th, when Mr. Kaup of the Crucible Steel Company of America presented a paper on "Steel and the Man; Their Character as Developed by Treatment." Mr. Kaup developed this subject in a very interesting and entertaining manner.

ST. LOUIS CHAPTER

A very interesting meeting of the St. Louis Chapter was held on Thursday evening, November 18th, at the American Annex Hotel, preceded by a dinner. The chapter was very fortunate in being able to obtain one of its local members to present a paper—Mr. J. M. Maher, superintendent of the St. Louis Frog & Switch Company—who illustrated his talk on "Personal Microscopic Studies of Heat Treated Steel."

At the same time as the announcement was sent out, the secretary mailed to each member a mimeographed list of the members of the St. Louis Chapter and their addresses.

PITTSBURGH CHAPTER

The October meeting of the Pittsburgh Chapter was addressed by Mr. C. M. Johnson of the Crucible Steel Company of America. Mr. Johnson presented the paper that he had presented at the Philadelphia Convention. A very interesting discussion was held at the close of the meeting.

The November meeting was held on the 23rd and was addressed by Mr. Charles McKnight, Jr., on the subject "Molybdenum in Steel."

NEW YORK CHAPTER

The New York Chapter held its regular monthly meeting at the Machinery Club, 30 Church street, New York, Wednesday evening, November 17th, when it was addressed by Mr. W. R. Moore, sales engineer, Norton Company, Worcester, Mass., in a lecture on "Grinding," illustrated with stereopticon views. The meeting was preceded by a dinner at the Machinery Club.

HARTFORD CHAPTER

The Hartford Chapter has prepared their program for the season of 1920-1921 and it shows the result of a great amount of careful thought and attention. Each meeting, which is assigned a definite date throughout the year, is divided into three parts. The first part being devoted to the practical development of steel from ore to the heat treater; the second part is for the discussion of the various elements as they effect the heat

treatment of steel, and the balance of the meeting is to be devoted to a general discussion of the "Are's and Aint's of Terminology" and to a general discussion of trials and tribulations of the members.

The motto adopted by the chapter is rather interesting and is as follows: "Don't be a sponge, but if you must, once in a while give yourself a squeeze." A reproduction of their program will be printed in the transactions.

IMPORTANT ANNOUNCEMENT

A return postal has been mailed to the entire membership, requesting them to send in complete information relative to their present positions and mailing addresses, so that we may have the proper data for the publication of the Year Book of the American Society for Steel Treating, which will be issued about January 15, 1921. These postals were mailed with copies of the Constitution which were sent to the entire membership.

IMPORTANT REQUEST

In the October issue of the transactions, page 67, a paper was published by Mr. Robert M. Taylor, works engineer, American Tool Works Company, Cincinnati, Ohio, on the subject "Steel for Machine Parts, Stationary and Moving, Carbonized and Heat Treated."

A large chart was to accompany the article, giving important specifications and results of investigations. If a sufficient number of requests are received, the article will be re-printed, and the blue print of the chart accompanying the article will be with the re-printed article. If you are interested, in securing a re-printed copy, drop a postal with your address, to the Headquarters of the Society, 4600 Prospect avenue, Cleveland, Ohio.

COMMERCIAL ITEMS

The E. F. Houghton Company have issued a 50-page booklet on the "Causes of Skin Sores and Boils Among Metal Workers." This text is a record of what is doubtless the most comprehensive investigation ever made of the subject. The foreword by Mr. Charles E. Carpenter, president of the company, outlines and summarizes the main features in plain, non-scientific language, easily understood by the practical man. Wherever the recommendations made are applied in a common-sense way, the problem of skin sores and boils among metal workers is cut down, and frequently overcome entirely. This booklet can be secured by writing the E. F. Houghton Company, Third, American and Somerset streets, Philadelphia, Pa.

The Roessler & Hasslacher Chemical Company, 709 Sixth avenue, New York, has issued an interesting booklet on "The Why and How of the Heat Treatment of Steel by Cyanide." Same can be had by writing above firm.

The American Dressler Tunnel Kilns, Inc., announce the removal of its executive engineering and thermal offices to 1740 East Twelfth street, Cleveland, Ohio.

Mr. W. S. Quigley, president, Quigley Furnace Specialties Company, New York City, has just returned from Europe, after an extensive trip made in connection with large installations of the Quigley Powdered Coal System in Italy and Belgium.

Mr. George H. Morgan has been elected treasurer of E. F. Houghton & Company, manufacturers of oils and leathers for the industries, Philadelphia. The position of secretary of the company, formerly held by Mr. Morgan, has been filled by the election by the board of directors of Mr. George W. Pressell, chief of the Houghton research staff. Mr. Morgan will retain the positon of managing director of the leather manufacturing department of Houghton & Company.

A site for the new building in Washington which is to serve as a home for the National Academy of Sciences and the National Research Council has recently been obtained. It comprises the entire block bounded by B and C streets and Twenty-first and Twenty-second streets, Northwest, and faces the Lincoln Memorial in Potomac Park. The Academy and Council have been enabled to secure this admirable site, costing about $200,000, through the generosity of the following friends and supporters: Thomas D. Jones, Harold F. McCormick, Julius Rosenwald and Charles H. Swift, Chicago; Charles F. Brush, George W. Crile, John L. Severance and Ambrose Swasey, Cleveland; Edward Dean Adams, Mrs. E. H. Harriman and the Commonwealth Fund, New York City; George Eastman and Adolph Lomb, Rochester; E. A. Doods and Charles F. Kettering, Dayton; Henry Ford, Detroit; Arthur H. Fleming, Pasadena; A. W. Mellon, Pittsburgh; Pierre S. duPont, Wilmington; Raphael Pumpelly, Newport; Mr. and Mrs. H. E. Huntington, Los Angeles; Corning Glass Works, Corning, N. Y. Funds for the erection of the building have been provided by the Carnegie Corporation of New York.

L. C. Wilson, for the past two years general sales manager of the Chain Belt Company, Milwaukee, has been elected secretary of the Federal Malleable Company, West Allis, Wis., manufacturers of malleable castings, malleable chains and the Rapid Molding Machine. He is to assume his new duties on November 15th and will be succeeded as sales manager at the Chain Belt Company by Clifford F. Messinger.

Mr. Wilson is a Yale graduate and began his business career as a salesman with Harbison-Walker Refractories Company, Pittsburgh. In 1917 he became associated with the Chain Belt Company and until his appointment as sales manager acted in the capacity of assistant to the vice-president. As the Federal Malleable Company is closely associated with the Chain Belt Company Mr. Wilson will continue to be in touch with Chain Belt friends.

Mr. Messinger is also a Yale graduate and has been with the Chain Belt Company since 1909 in various capacities including that of advertising manager, manager of Rex Concrete Mixer sales and assistant to the vice-president.

EMPLOYMENT SERVICE BUREAU

The Employment Service Bureau is free to all members of the AMERICAN STEEL TREATERS' SOCIETY. If you desire to change position or location, write the Business Manager and your case will be given personal and prompt attention.

Mr. Manufacturer: If you need an efficient Factory Manager, Works Manager, Chief Engineer, Metallurgist, Chemist, Foreman of Heat Treating Rooms, Furnace Man or Sales Representative, write us. We will put you in touch with the right man, and there will be no charge for the service.

POSITIONS OPEN

WANTED—Assistant Superintendent of Forge Department, University of Illinois, on September 1st, 1920. Young man not over 28 years old, of good personality and character, who wants to follow the teaching profession. Must understand forging practice, though great skill not necessary. An ambitious apprentice with a High School education and a knowledge of the principles of forge shop practice would be given consideration. Address 9-25.

Wanted—Foreman for hardening department, by large tractor manufacturing concern. When replying, give age, experience, etc. Address 10-70.

POSITIONS WANTED

POSITION WANTED—California location desired—as superintendent or foreman of heat-treating department by a steel treater with more than 20 years' experience. Have specialized in carbonizing and the construction of special furnaces for steel treating. Address 11-60.

WANTED—Position by man at present employed as Foreman of the Heat Treating Department of a firm where he has been for the past ten years. Besides experience in the heat treating of steel, has had experience in the chemical and physical testing of steel, inspection of small and large forgings, and a little of photomicrography. Address No. 10-25.

WANTED—Position as Assistant Metallurgist, preferably in Pittsburgh District. Graduate in metallurgy with several years' experience in heat treating, metallography and pyrometry. At present assistant to metallurgist of well-known concern. Address No. 10-10.

WANTED—Position as Metallurgist. Have been employed by well-known Motor Car Companies as Assistant Metallurgist and later Metallurgist. Can give the best of references. Address No. 10-15.

POSITION WANTED—Technically educated young man, with four years' practical experience in the heat treatment of plain carbon and alloy marine, locomotive and machine forgings, wishes to obtain new location with more opportunities for the future. Am especially qualified to supervise hardening of die blocks before and after sinking of impression, and physical testing. Address No. 10-5.

WANTED—Graduate Mining and Metallurgy, Ohio State University, with experience as Construction Engineer, Contracting Engineer, with large firms. Also as Chief Engineer of a large steel company, besides work in the ordnance office during the war. Has had excellent success in handling help in organizing a project. Can handle sales work, production or manager. Address 9-45.

WANTED—Position in heat treating and laboratory control, covering chemical and metallographic work. Best of references. Address 9-50.

WANTED—Position as Metallographist in Pittsburgh or vicinity. Have had a number of years experience in this line of work, and at present employed with a nationally known testing laboratory. Address 9-30.

WANTED—Position as foreman, or position giving an opportunity to work up to foreman. Have had 7½ years' experience as foreman of heat treating department, covering tool work, heat treating of large turbine parts, drill parts and also experience in electric and acetylene welding. Address 9-35.

WANTED—Position as Hardener in charge of hardening room. Eastern territory desired. Have had two years' experience in modern heat treating plants. Completed course in Metallography. At present foreman heat treating department. Best of references. Address 9-00.

WANTED—Position as Superintendent of heat treating department. Have had eight years' experience in charge of department of large tool company. Best of references. Address 9-05.

WANTED—Position as Hardener or in charge of Hardening Room. Have had a number of years' valuable experience on high speed and carbon steels; also carbonizing and case hardening of all kinds. At present connected with large motor car company. New York vicinity preferred. Address 915.

WANTED—Position as Metallurgical Engineer in technical or executive capacity. Seven years' experience in electric and crucible tool steel and open hearth production. Experienced in research, metallography, pyrometry, magnetic testing, critical point determinations, mill problems, complaint and service work, hot rolling and cold wire drawing operations. Laboratory installations, standardization of heat treatment of tool steels. At present metallurgist for well known tool steel plant. Married. Age 32. Address 9-10.

WANTED—Position as Superintendent, Foreman or Steel Salesman by party having 20 years' experience in forging and blacksmith shop and heat treating departments. Best of references. Address 9-75.

WANTED—Position as Metallurgist, preferably in the Automotive industry. Applicant is a graduate chemist (B. S. in Chem.), a thorough metallurgical analyst and metallographist. Has had six years' experience in iron and steel analysis, physical testing metallography and heat treatment. Has been in charge of large laboratory for two years, and engaged in important research on the heat treatment of carbon and alloy steels. Can give excellent references, and would be glad to furnish further information. Address No. 610.

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